*This form must be completed in **ink** and changes must be **initialed**.*

Honorable Board of Directors
Santa Clara Valley Water District (District)

Pursuant to, and in compliance with, the Notice to Bidders and the Contract Documents, relating to the

C0663 – ANDERSON DAM TUNNEL PROJECT, the undersigned Bidder having become thoroughly familiar with the terms and conditions of the Contract Documents and with local conditions affecting the performance and costs of the Work and having fully inspected the Work site in all particulars, hereby proposes and agrees to fully perform the Work, including providing any and all labor and materials and performing all Work required to construct and complete said Work within the contract time stated and in accordance with the requirements of the Contract Documents, for the following sum of money.

The undersigned Bidder agrees to complete all the Work within **1,710** calendar days from the first chargeable day of the Contract, as stated in the Notice to Begin Work. The Bidder agrees to enter into a Contract with the District and provide the required bonds and insurance in accordance with the Instructions to Bidders, Contract Bonds, paragraph #22 and Execution of Contract, paragraph #23. If the Bidder fails to meet these requirements within the time specified in the Instruction to Bidders, Failure to Execute Contract, paragraph #24, the Bidder's security accompanying this Proposal may be forfeited and become the property of the District. No Contract exists until all Contract bonds and insurance documents have been accepted by the District.

TOTAL BID: $ 172,749,219.06

Bidder acknowledges receipt of the following Addenda to the Bid Documents:

Addenda are posted online at https://www.valleywater.org/construction.

☐ **NO** Addenda received

☒ Addenda received as follows:

Addendum No. 1	Date 2/17/2021	Addendum No. 5	Date 3/16/2021
Addendum No. 2	Date 2/23/2021	Addendum No. 6	Date 3/17/2021
Addendum No. 3	Date 3/2/2021	Addendum No. 7	Date 3/24/2021
Addendum No. 4	Date 3/9/2021	Addendum No. 8	Date 3/25/2021

Failure to acknowledge receipt of an Addendum on the Bid Form is not, in itself, cause for withdrawal or rejection of Bid, if it can be established that Bidder did, in fact, receive such Addendum prior to Bid opening.

BIDDER'S COMPANY INFORMATION	
NAME: Kiewit Infrastructure West Co.	ADDRESS: 4650 Business Center Dr. Fairfield, CA 94534
CONTRACTOR'S CALIFORNIA LICENSE NUMBER: 433176 DATE OF EXPIRATION: 1/31/2023 LICENSE CLASSIFICATION(S): A, B, C10, C31, C36, HAZ	
PHONE NO.: (707) 439-7300	FAX NO.: (707) 439-7301
EMAIL ADDRESS: ncestimating@kiewit.com	
SIGNATURE BLOCK (Signature Block must be completed in *ink* and changes must be *initialed*.)	
Bidder's Signature: Eric M Scott	Date: 3/30/21
Bidder's Name and Title (Print): Eric M. Scott, Sr. Vice President	

*This form must be completed in **ink** and changes must be **initialed**.*

SECTION A — BASE BID

ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
1	**MOBILIZATION AND DEMOBILIZATION**			
1a	Mobilization and Demobilization	Lump Sum Lump Sum	$ 16,485,000.00	16,485,000.00
1b	Contractor – Obtained Permits	Lump Sum Lump Sum	$ 100,000.00	100,000.00
2	**SITE PREPARATION**			
2a	Demolition	Lump Sum Lump Sum	$ 250,000.00	250,000.00
2b	Clearing and Grubbing	16 ACRES	$ 4,750.00	76,000.00
2c	Stripping	27,000 SY	$ 9.00	243,000.00
2d	Install Active Treatment System (ATS)	Lump Sum Lump Sum	EMS ~~500,000.00~~ $ 750,000.00	~~500,000.00~~ EMS 750,000.00
2e	Operate Active Treatment System (ATS)	32 MO	$ 53,000.00	1,696,000.00
2f	Coyote Road Turnouts	Lump Sum Lump Sum	$ 50,000.00	50,000.00
2g	Giancola Driveway and Waterline	Lump Sum Lump Sum	$ 150,000.00	150,000.00
2h	Compliance with NPDES General Permit	32 MO	$ 51,000.00	1,632,000.00
2i	Migratory Birds	32 MO	EMS ~~1,800.00~~ $ 3,000.00	~~57,600.00~~ EMS 96,000.00
2j	Noise and Vibration Monitoring	32 MO	~~16,000~~ EMS $ 25,000.00	~~512,000.00~~ EMS 800,000.00

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ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
2k	Dust Control and Air Monitoring	32 MO	EMS ~~$ 1,000.00~~ $ 100,000.00	EMS ~~$ 32,000.00~~ 3,200,000.00
3	**DIVERSION PORTAL**			
3a	Geotechnical Borings	985 LF	$ 340.00	334,900.00
3b	Diversion Portal Excavation	89,500 CY	$ 12.00	1,074,000.00
3c	Soil Nails #20, 120ft	43 EA	$ 12,000.00	516,000.00
3d	Soil Nails #18, 120ft	81 EA	10,000.00 $	810,000.00
3e	Soil Nails #14, 120ft	121 EA	$ 9,000.00	1,089,000.00
3f	12-inch Shotcrete and #6 Rebar Mat	42,650 SF	$ 50.00	2,132,500.00
3g	Diversion Tunnel Portal Reinforced Concrete Encasement	Lump Sum Lump Sum	$ 750,000.00	750,000.00
3h	Hydraugers	42 EA	$ 2,100.00	88,200.00
3i	Diversion Portal Instrumentation	Lump Sum Lump Sum	$ 750,000.00	750,000.00
3j	Temporary Tunneling Portal Support	Lump Sum Lump Sum	$ 300,000.00	300,000.00
3k	Diversion Portal Hydroseed	2.94 ACRES	5,600.00 $	16,464.00
4	**LAKE – TAP PORTAL**			
4a	Core Borings (Over Water)	150 LF	$ 900.00	135,000.00

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ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
4b	Turbidity Barrier	Lump Sum Lump Sum	$ 1,200,000.00	1,200,000.00
4c	Lake-Tap Excavation (Dredging) and MTBM Landing Pad	16,900 CY	$ 44.00	743,600.00
4d	Lake-Tap Rock Backfill	810 CY	$ 314.00	254,340.00
4e	Diversion Intake Trash Rack	Lump Sum Lump Sum	$ 3,000,000.00	3,000,000.00
5	**TUNNEL EXCAVATION AND LINING**			
5a	18.5-foot Diameter Tunnel Excavation - Class 3	70 LF	$ 5,985.00	418,950.00
5b	18.5-foot Diameter Tunnel Excavation - Class 4	215 LF	$ 8,770.00	1,885,550.00
5c	18.5-foot Diameter Tunnel Excavation - Class 5	70 LF	$ 27,000.00	1,890,000.00
5d	24-foot Diameter Tunnel Excavation - Class 3	150 LF	$ 10,000.00	1,500,000.00
5e	24-foot Diameter Tunnel Excavation - Class 4	550 LF	$ 11,000.00	6,050,000.00
5f	24-foot Diameter Tunnel Excavation - Class 5	450 LF	$ 11,856.00	5,335,200.00
5g	#8 Rock Dowels	210 EA	$ 2,700.00	567,000.00
5h	Shotcrete in Transition Zone	175 CY	$ 3,100.00	542,500.00
5i	Reinforced Concrete Liner in Tunnel	675 LF	$ 7,300.00	4,927,500.00
5j	5-foot Articulated Joint Segments	85 LF	$ 18,000.00	1,530,000.00

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ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
5k	10-foot Articulated Joint Segments	460 LF	$ 12,000.00	5,520,000.00
5l	LLOT Downstream Leg Reinforced Concrete Plug	Lump Sum Lump Sum	$ 150,000.00	150,000.00
5m	13-foot Steel Liner and Concrete Backfill within Tunnel	Lump Sum Lump Sum	$ 6,700,000.00	6,700,000.00
5n	CLSM Backfill in Transition Zone	450 CY	$ 490.00	220,500.00
5o	Probing Within Rock Tunnel	4,950 LF	$ 46.00	227,700.00
5p	Waterproofing Membrane and Drainage Collection System	1,220 LF	$ 1,900.00	2,318,000.00
5q	Diversion Air Vent and Observation Well	Lump Sum Lump Sum	$ 550,000.00	550,000.00
5r	Pre-excavation Drilling Within Rock Tunnel, Direct Cost	4,000 LF	$ 46.00	184,000.00
5s	Pre-excavation Drilling and Grouting Within Rock Tunnel, Indirect Cost	150 SHIFTS	$ 13,000.00	1,950,000.00
5t	Pre-excavation Grouting Within Rock Tunnel, Microfine Cement	4,000 SACKS	$ 76.00	304,000.00
5u	Pre-excavation Grouting Within Rock Tunnel, Chemical Grout	5,300 GALLONS	$ 18.00	95,400.00
5v	Tunnel Excavation in Transition Zone – Class 3	505 CY	$ 159.00	80,295.00
5w	Tunnel Excavation in Transition Zone – Class 4	840 CY	$ 195.00	163,800.00
5x	Tunnel Excavation in Transition Zone – Class 5	340 CY	EMS ~~$ 230.00~~ $ 350.00	~~78,000.00~~ EMS 119,000.00

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ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
5y	Tunneling Standby	30 DAYS	$ 26,500.00	795,000.00
6	**SHAFT EXCAVATION AND LINING**			
6a	Shaft Excavation, Initial Support, Final Lining and Backfill	Lump Sum Lump Sum	$ 8,334,000.00	8,334,000.00
7	**MICROTUNNEL**			
7a	Microtunneling Mobilization and Demobilization	Lump Sum Lump Sum	$ 3,687,000.00	3,687,000.00
7b	Microtunneling (8 to 9-ft Inside Diameter)	372 LF	$ 25,000.00	9,300,000.00
8	**DIVERSION OUTLET STRUCTURE**			
8a	Diversion Outlet Structure Excavation	21,500 CY	$ 12.00	258,000.00
8b	Soil Nails #14, 20 ft	72 EACH	$ 2,900.00	208,800.00
8c	6-inch Shotcrete and #6 Rebar Mat	5,150 SF	$ 24.00	123,600.00
8d	CLSM Backfill for Diversion Outlet Structure	9,650 CY	$ 158.00	1,524,700.00
8e	Earthfill Backfill for Diversion Outlet Structure	6,200 CY	$ 16.00	99,200.00
8f	Diversion Outlet Structure Concrete Foundation	3,600 CY	$ 700.00	2,520,000.00
8g	Diversion Outlet Structure Foundation Anchors	114 EACH	$ 6,500.00	741,000.00
8h	Diversion Outlet Structure	Lump Sum Lump Sum	$ 6,000,000.00	6,000,000.00

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ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
8i	132-inch Butterfly Valves	Lump Sum Lump Sum	4,000,000 00 $	4,000,000 00
8j	132-inch Fixed Cone Valves	Lump Sum Lump Sum	$ 10,000,000 00	10,000,000 00
8k	156-inch Steel Pipe	50 LF	$ 36,500 00	1,825,000 00
8l	132-inch Steel Pipe	180 LF	$ 19,000 00	3,420,000 00
8m	Special Seismic Steel Pipe	Lump Sum Lump Sum	$ 12,000,000 00	12,000,000 00
8n	24-inch Sleeve Valve	Lump Sum Lump Sum	650,000 00 $	650,000 00
8o	Miscellaneous Mechanicals	Lump Sum Lump Sum	500,000 00 $	500,000 00
8p	Electrical Equipment	Lump Sum Lump Sum	4,000,000 00 $	4,000,000 00
8q	Instrumentation and Controls	Lump Sum Lump Sum	3,000,000 00 $	3,000,000 00
8r	Diversion Outlet Structure Access Road and Permanent Fencing	Lump Sum Lump Sum	200,000 00 $	200,000 00
8s	Hydrostatic Testing	Lump Sum Lump Sum	1,700,000 00 $	1,700,000 00
9	**COYOTE CREEK MODIFICATIONS**			
9a	Temporary Dike and Dewater Northern Channel	Lump Sum Lump Sum	1,342,000 00 $	1,342,000 00
9b	Realign Anderson Force Main (AFM)	Lump Sum Lump Sum	3,000,000 00 $	3,000,000 00
9c	Discharge Channel and Northern Channel Excavation	41,950 CY	11 00 $	461,450 00

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ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
9d	Northern Channel Substrate	3,450 CY	$ 100.00	345,000.00
9e	Northern Weir and Southern Weir	Lump Sum Lump Sum	$ 660,000.00	660,000.00
9f	Permanent Dikes Abutting Southern Weir	Lump Sum Lump Sum	$ 50,000.00	50,000.00
9g	Riprap Type 1	3,600 CY	$ 156.00	561,600.00
9h	Riprap Type 2	9,750 CY	$ 159.00	1,550,250.00
9i	Riprap Type 3	1,350 CY	$ 159.00	214,650.00
9j	Riprap Type 4	60 CY	$ 164.00	9,840.00
9k	Boulder Grade Control	200 TONS	$ 175.00	35,000.00
9l	Turf Reinforcement Matting	3,700 SY	$ 40.00	148,000.00
9m	Coyote Creek Hydroseed	0.75 ACRES	$ 5,600.00	4,200.00
		SECTION A SUBTOTAL	$	165,219,689.00

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SECTION B — SUPPLEMENTAL BID ITEMS
These Bid items may or may not be required. They may be deleted entirely or in part, by deductive change order(s), at the sole discretion of the District.

ITEM NO.	DESCRIPTION OF ITEM	APPROXIMATE QUANTITY UNIT	UNIT PRICE	TOTAL
10	**SUPPLEMENTAL WORK**			
10a	Landslide Excavation, Hoot Owl Way	21,650 CY	$ 12.00	259,800.00
10b	Landslide Excavation, Boat Marina	4,330 CY	$ 16.00	69,280.00
10c	Landslide Remediation, Soil Nails #8, 100 feet	737 EACH	$ 4,800.00	3,537,600.00
10d	Landslide Remediation, Soil Nails #8, 140 feet	248 EACH	$ 6,800.00	1,686,400.00
10e	Landslide Remediation, Earthfill for Hoot Owl Way	21,850 CY	$ 17.00	371,450.00
10f	Landslide Remediation, Earthfill for Boat Marina	4,400 CY	$ 18.00	79,200.00
10g	Existing Intake Improvements, Soil Nails #8, 75 feet	45 EACH	$ 7,000.00	315,000.00
10h	Existing Intake Improvements, Soil Nails #8, 100 feet	46 EACH	$ 9,000.00	414,000.00
10i	Existing Intake Improvements, Soil Nails #14, 75 feet	4 EACH	$ 11,000.00	44,000.00
10j	Existing Intake Improvements, Structural/Mechanical Alterations	Lump Sum Lump Sum	$ 115,000.00	115,000.00
10k	Supplemental Work Hydroseed	6.3 ACRES	$ 6,000.00	37,800.00
		SECTION B SUBTOTAL		$ 6,929,530.00

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SECTION C — ALLOWANCES				
ITEM NO.	**DESCRIPTION OF ITEM**	**APPROXIMATE QUANTITY UNIT**	**UNIT PRICE**	**TOTAL**
11	**ALLOWANCES**			
11a	Other Wildlife and Fish Species (19.09)	1	**$250,000.00**	**$250,000.00**
11b	Sensitive Plants and Vegetation (19.10)	1	**$250,000.00**	**$250,000.00**
11c	Dispute Review Board	1	**$75,000.00**	**$75,000.00**
11d	Facilitated Partnering	1	**$25,000.00**	**$25,000.00**
			SECTION C SUBTOTAL	**$600,000.00**
TOTAL BID (SECTIONS A SUBTOTAL + B SUBTOTAL + C SUBTOTAL)				**$ 172,749,219.00**

mass.
electric
construction
company

Kiewit Infrastructure West Co.
4650 Business Center Dr.
Fairfield, CA 94536

RE: Electrical Subcontractor Affidavit of Technical and Financial Capability
Anderson Dam Tunnel Project

Ladies and Gentlemen:

Mass Electric Construction Co. provided the following sworn statement confirming that as a bidding Electrical Subcontractor on the Anderson Dam Tunnel Project, we have the technical knowledge and the financial capability to furnish and install all electrical equipment specified in Division 16 and shown on the electrical drawings for this project (per Spec Section 16010-9, Item 1.10, G).

Sincerely,

Brandon T. Parker
Mass. Electric Construction Co.
Area Manager

MASS. ELECTRIC CONSTRUCTION CO.
1925 Wright Ave, Suite C, La Verne, CA 91750
CA License #819912 DIR #1000001289

CALIFORNIA NOTARIAL CERTIFICATE
(JURAT)

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California
County of Solano

Subscribed and sworn to (or affirmed) before me on this 30th day of March, 2021, by Brandon T. Parker, proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

Signature _____. (Seal)

CORI BEEBY
Notary Public - California
Solano County
Commission # 2248179
My Comm. Expires Jun 29, 2022

Designation of Subcontractors

*This form must be completed in **ink** and changes must be **initialed**.*

A. This Designation of Subcontractors form must be completed in compliance with the State of California Subletting and Subcontracting Fair Practices Act, Public Contract Code **§4100 et seq.**, and any amendment thereof. Bidder must complete the form below for each Subcontract **that exceeds one-half of one percent (½%) of the Bidder's total Bid**. A Subcontractor is one who: (1) performs Work or labor; or (2) provides a service to the Bidder; or (3) specially Fabricates and Installs a portion of the work according to the Contract Documents. Bidders failure to list a Subcontractor for any portion of the work in excess of ½% of Bidder's total Bid signifies Bidder will self perform that portion of the Work with its own forces. (Note: If more than one Subcontractor is designated for the same kind of Work, state the portion that each will perform.) After the opening of the Bids, no changes or substitutions will be allowed except as otherwise provided by law. The listing of more than one subcontractor for each item of work to be performed with the words "and/or" will not be permitted. Failure to comply with this requirement may render the Bid nonresponsive and may cause its rejection.

B. Failure by a subcontractor to be registered to perform public work as required by the California Labor Code Section 1771.1 (a) shall be grounds under Section 4107 of the Public Contract Code for the Contractor, with the consent of the awarding authority, to substitute a subcontractor who is registered to perform public work pursuant to Section 1725.5 in place of the unregistered subcontractor.

NAME LOCATION (City & State)	LICENSE NO. EXPIRATION DATE	DIR REGISTRATION NO. EXPIRATION DATE	TYPE OF WORK	% of TOTAL CONTRACT
Vadnais Trenchless Services Inc. Lake Forest, CA	997903 10-31-22	1000030849 6-30-21	microtunneling	5.35%
Renesco Inc. Chantilly, VA	1053005 4-30-21	1000564720 6-30-21	PVC Membrane Waterproofing System	0.86%
Pacific Steel Group Fairfield, CA	997880 10-31-22	1000004101 6-30-21	Rebar	3.35%

SIGNATURE BLOCK (Signature Block must be completed in *ink* and changes must be *initialed*.)	
Bidder's Signature: Eric M Scott	Date: 3/30/21
Bidder's Name and Title (Print): Eric M. Scott, Sr. Vice President	

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A. This Designation of Subcontractors form must be completed in compliance with the State of California Subletting and Subcontracting Fair Practices Act, Public Contract Code **§4100 et seq.**, and any amendment thereof. Bidder must complete the form below for each Subcontract **that exceeds one-half of one percent (½%) of the Bidder's total Bid**. A Subcontractor is one who: (1) performs Work or labor; or (2) provides a service to the Bidder; or (3) specially Fabricates and Installs a portion of the work according to the Contract Documents. Bidders failure to list a Subcontractor for any portion of the work in excess of ½% of Bidder's total Bid signifies Bidder will self perform that portion of the Work with its own forces. (Note: If more than one Subcontractor is designated for the same kind of Work, state the portion that each will perform.) After the opening of the Bids, no changes or substitutions will be allowed except as otherwise provided by law. The listing of more than one subcontractor for each item of work to be performed with the words "and/or" will not be permitted. Failure to comply with this requirement may render the Bid nonresponsive and may cause its rejection.

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NAME LOCATION (City & State)	LICENSE NO. EXPIRATION DATE	DIR REGISTRATION NO. EXPIRATION DATE	TYPE OF WORK	% of TOTAL CONTRACT
Malcolm Drilling Company, Inc. Hayward, CA	259543 7-31-22	1000003389 6-30-22	Soil Nails Shotcrete Hydraugers	6.27%
			Diversion air vent & observation well	
Mass Electric Construction Co. Waltham, MA	819912 5-31-21	1000001289 6-30-22	Electrical (Labor Only)	0.55%

SIGNATURE BLOCK (Signature Block must be completed in *ink* and changes must be *initialed*.)	
Bidder's Signature: Eric M Scott	Date: 3/30/21
Bidder's Name and Title (Print): Eric M. Scott, Sr. Vice President	

Noncollusion Affidavit

*This form must be completed in **ink** and changes must be **initialed**.*

In accordance with Public Contract Code Section 7106, Eric M. Scott
(Bidder's full name)

declares that he ~~or she~~ is Sr. Vice President
(Bidder's title)

of Kiewit Infrastructure West Co.
(Company's name)

the party making the foregoing Bid that the Bid is not made in the interest of, or on behalf of, any disclosed person, partnership, company, association, organization, or corporation; that the Bid is genuine and not collusive or sham; that the Bidder has not directly or indirectly induced or solicited any other Bidder to put in a false or sham bid, and has not directly or indirectly colluded, conspired, connived, or agreed with any Bidder or anyone else to put in a sham bid, or that anyone shall refrain from bidding; that the Bidder has not in any manner, directly or indirectly, sought by agreement, communication, or conference with anyone to fix the Bid price of the Bidder or any other Bidder, or to fix any overhead, profit, or cost element of the Bid price, or of that of any other Bidder, or to secure any advantage against the public body awarding the contract of anyone interested in the proposed contract; that all statements contained in the Bid are true; and, further, that the Bidder has not, directly or indirectly, submitted the Bid price or any breakdown thereof, or the contents thereof, or divulged information or data relative thereto, or paid, and will not pay, any fee to any corporation, partnership, company association, organization, Bid depository, or to any member or agent thereof to effectuate a collusive or sham bid.

I certify (or declare) under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

SIGNATURE BLOCK (Signature Block must be completed in *ink* and changes must be *initialed*.)	
Bidder's Signature: Eric M Scott	Date: 3/30/21
Bidder's Name and Title (Print): Eric M. Scott, Sr. Vice President	

*This form must be completed in **ink** and changes must be **initialed**.*

BE IT KNOWN BY THESE PRESENTS,

That we, Kiewit Infrastructure West Co., as PRINCIPAL,
and Travelers Casualty and Surety Company of America, as SURETY,

are held and firmly bound unto the Santa Clara Valley Water District, hereinafter called the District, in the penal sum of TEN PERCENT (10%) OF THE TOTAL AMOUNT OF THE PROPOSAL of the Principal above named, submitted by said Principal to the Santa Clara Valley Water District, for the work described below, for the payment of which sum is lawful money of the United States, well and truly to be made, we bind ourselves, our heirs, executors, administrators and successors, jointly and severally, firmly by these presents. In no case shall the liability of the surety hereunder exceed the sum of $ Ten percent of bid --- (10% of bid ---)

THE CONDITION OF THIS OBLIGATION IS SUCH,

That whereas the Principal has submitted the above mentioned Proposal to the District, for certain construction specifically described as follows, for which Proposals are to be opened at San Jose, California, on 3/30, 20 21 (or such other date as specified per Addendum) for Anderson Dam Tunnel Project.

NOW, THEREFORE, if the aforesaid Principal is awarded the Contract and, within the time and manner required under the Contract Documents, after the prescribed forms are presented to him for signature, enters into a written contract, in the prescribed form, in accordance with the Proposal, and files originals (copies are unacceptable) of the two bonds with the District, one to guarantee faithful performance and the other to guarantee payment for labor and materials, as required by law, then this obligation shall be null and void; otherwise, it shall be and remain in full force and virtue.

In the event suit is brought upon this bond by the obligee and judgment is recovered, the surety shall pay all costs incurred by the obligee in such suit, including a reasonable attorney's fee to be fixed by the court.

IN WITNESS WHEREOF, we have hereunto set our hands and seal on the 22nd day of March, 2021

PRINCIPAL: Kiewit Infrastructure West Co.

Eric M Scott
Signature

Eric M. Scott
Name

Senior Vice President
Title

4650 Business Center Drive
Fairfield, CA 94534
Address

Travelers Casualty and Surety Company of America
SURETY: A.M. Best Rating A++, XV

Deanne Jones
Signature

Deanne Jones
Name (Seal)

Attorney-in-Fact
Title

One Tower Square
Hartford, CT 06183
Address

NOTE: 1. Original Bidder's Bond documents are required; copies are unacceptable.
2. Signature of those executing for Surety must be properly acknowledged

TRAVELERS

Travelers Casualty and Surety Company of America
Travelers Casualty and Surety Company
St. Paul Fire and Marine Insurance Company

POWER OF ATTORNEY

KNOW ALL MEN BY THESE PRESENTS: That Travelers Casualty and Surety Company of America, Travelers Casualty and Surety Company, and St. Paul Fire and Marine Insurance Company are corporations duly organized under the laws of the State of Connecticut (herein collectively called the "Companies"), and that the Companies do hereby make, constitute and appoint **Philip G. Dehn, Tammy Pike, Paul A. Foss, Marie Huggins, Traci Sutton, and Deanne Jones** of **Omaha, Nebraska** their true andlawful Attorney-in-Fact to sign, execute, seal and acknowledge any and allbonds, recognizances, conditional undertakings and other writings obligatoryin the nature thereof on behalf of the Companies in their business of guaranteeing the fidelity of persons,guaranteeing the performance of contractsand executing or guaranteeing bonds and undertakings required or permitted in any actions or proceedings allowed by law.

IN WITNESS WHEREOF, the Companies have caused this instrument to be signed, and their corporate seals to be hereto affixed, this **3rd** day of **February, 2017.**

State of Connecticut

City of Hartford ss.

By: _____
Robert L. Raney, Senior Vice President

On this the **3rd** day of **February, 2017**, before me personally appeared **Robert L. Raney**, who acknowledged himself to be the Senior Vice President of Travelers Casualty and Surety Company of America, Travelers Casualty and Surety Company, and St. Paul Fire and Marine Insurance Company, and that he, as such, being authorized so to do, executed the foregoing instrument for the purposes therein contained by signing on behalf of the corporations by himself as a duly authorized officer.

In Witness Whereof, I hereunto set my hand and official seal.

My Commission expires the **30th** day of **June, 2021**

Marie C Tetreault
Marie C. Tetreault, Notary Public

This Power of Attorney is granted under and by the authority of the following resolutions adopted by the Boards of Directors of Travelers Casualty and Surety Company of America, Travelers Casualty and Surety Company, and St. Paul Fire and Marine Insurance Company, which resolutions are now in full force and effect, reading as follows:

RESOLVED, that the Chairman, the President, any Vice Chairman, any Executive Vice President, any Senior Vice President, any Vice President, any Second Vice President, the Treasurer, any Assistant Treasurer, the Corporate Secretary or any Assistant Secretary may appoint Attorneys-in-Fact and Agents to act for and on behalf of the Company and may give such appointee such authority as his or her certificate of authority may prescribe to sign with the Company's name and seal with the Company's seal bonds, recognizances, contracts of indemnity, and other writings obligatory in the nature of a bond, recognizance, or conditional undertaking, and any of said officers or the Board of Directors at any time may remove any such appointee and revoke the power given him or her; and it is

FURTHER RESOLVED, that the Chairman, the President, any Vice Chairman, any Executive Vice President, any Senior Vice President or any Vice President may delegate all or any part of the foregoing authority to one or more officers or employees of this Company, provided that each such delegation is in writing and a copy thereof is filed in the office of the Secretary; and it is

FURTHER RESOLVED, that any bond, recognizance, contract of indemnity, or writing obligatory in the nature of a bond, recognizance, or conditional undertaking shall be valid and binding upon the Company when (a) signed by the President, any Vice Chairman, any Executive Vice President, any Senior Vice President or any Vice President, any Second Vice President, the Treasurer, any Assistant Treasurer, the Corporate Secretary or any Assistant Secretary and duly attested and sealed with the Company's seal by a Secretary or Assistant Secretary; or (b) duly executed (under seal, if required) by one or more Attorneys-in-Fact and Agents pursuant to the power prescribed in his or her certificate or their certificates of authority or by one or more Company officers pursuant to a written delegation of authority; and it is

FURTHER RESOLVED, that the signature of each of the following officers: President, any Executive Vice President, any Senior Vice President, any Vice President, any Assistant Vice President, any Secretary, any Assistant Secretary, and the seal of the Company may be affixed by facsimile to any Power of Attorney or to any certificate relating thereto appointing Resident Vice Presidents, Resident Assistant Secretaries or Attorneys-in-Fact for purposes only of executing and attesting bonds and undertakings and other writings obligatory in the nature thereof, and any such Power of Attorney or certificate bearing such facsimile signature or facsimile seal shall be valid and binding upon the Company and any such power so executed and certified by such facsimile signature and facsimile seal shall be valid and binding on the Company in the future with respect to any bond or understanding to which it is attached.

I, **Kevin E. Hughes**, the undersigned, Assistant Secretary of Travelers Casualty and Surety Company of America, Travelers Casualty and Surety Company, and St. Paul Fire and Marine Insurance Company, do hereby certify that the above and foregoing is a true and correct copy of the Power of Attorney executed by said Companies, which remains in full force and effect.

Dated this 22nd day of March , 2021

Kevin E. Hughes
Kevin E. Hughes, Assistant Secretary

To verify the authenticity of this Power of Attorney, please call us at 1-800-421-3880.
Please refer to the above-named Attorney-in-Fact and the details of the bond to which the power is attached.

NOTARY ACKNOWLEDGMENT

STATE OF NEBRASKA

COUNTY OF DOUGLAS

I, Traci L. Sutton, a Notary Public in and for said County and State, do hereby certify that Deanne Jones, Attorney-in-Fact of Travelers Casualty and Surety Company of America, proved to me on the basis of satisfactory evidence to be the person who appeared before me, and acknowledged that she signed, sealed and delivered a said instrument, for and on behalf of Travelers Casualty and Surety Company of America for the uses and purposes therein set forth.

Given under my hand and notarial seal, the 22nd day of March, 2021.

Traci L. Sutton

Traci L. Sutton, Notary Public

GENERAL NOTARY - State of Nebraska
TRACI L. SUTTON
My Comm. Exp. November 20, 2024

*This form must be completed in **ink** and changes must be **initialed**.*

Iran Contracting Act Bid Certification
(Public Contract Code Sections 2202–2208)
Must be Completed for any Proposal of $1,000,000 or more

Public Contract Code (PCC) Sections 2200–2208 are known as the Iran Contracting Act of 2010 and prohibit public entities from contracting with companies that have specified business activities in Iran's petroleum sector. Companies seeking to bid on state or local government contracts are required to certify that they are not engaged in developing Iran's petroleum resources.

Prior to bidding on, submitting a proposal or executing a contract or renewal for a Santa Clara Valley Water District contract for goods or services of one million dollars ($1,000,000 or more), a person (vendor, firm, corporation, etc.) must either: a) certify it is **not** on the current list of persons engaged in investment activities in Iran created by the California Department of General Services ("DGS") pursuant to Public Contract Code Section 2203(b) and is not a financial institution extending twenty million dollars ($20,000,000) or more in credit to another person, for 45 days or more, if that other person will use the credit to provide goods or services in the energy sector in Iran and is identified on the current list of persons engaged in investment activities in Iran created by DGS; or b) demonstrate it has been exempted from the certification requirement for that solicitation or contract pursuant to Public Contract Code Section 2203(c) or (d). The DGS list is posted online at: (www.dgs.ca.gov, search "Iran Contracting Act List").

To comply with this requirement, please complete **one** of the options below. Please note: California law establishes penalties for providing false certifications, including civil penalties equal to the greater of $250,000 or twice the amount of the contract for which the false certification was made; contract termination; and three-year ineligibility to bid on contracts. (Public Contract Code Section 2205.)

Iran Contracting Act Bid Certification

*This form must be completed in **ink** and changes must be **initialed**.*

Please complete one of the options below (see prior page for additional explanation).

OPTION NO.1—CERTIFICATION

I, the official named below, certify I am duly authorized to execute this certification on behalf of the person/financial institution identified below, and the person/financial institution identified below is **not** on the current list of persons engaged in investment activities in Iran created by DGS and is not a financial institution extending twenty million dollars ($20,000,000) or more in credit to another person/vendor, for 45 days or more, if that other person/vendor will use the credit to provide goods or services in the energy sector in Iran and is identified on the current list of persons engaged in investment activities in Iran created by DGS.

Name of Person (Vendor, Firm, Corporation, etc.)/Financial Institution (Printed):	Federal ID No. (or n/a):
Kiewit Infrastructure West Co.	47-0647803
By (Authorized Signature): Eric M Scott	
Printed Name and Title of Person Signing: Eric M. Scott, Sr. Vice President	
Date Executed: 3/30/2021	Executed in (City & State): Fairfield, CA

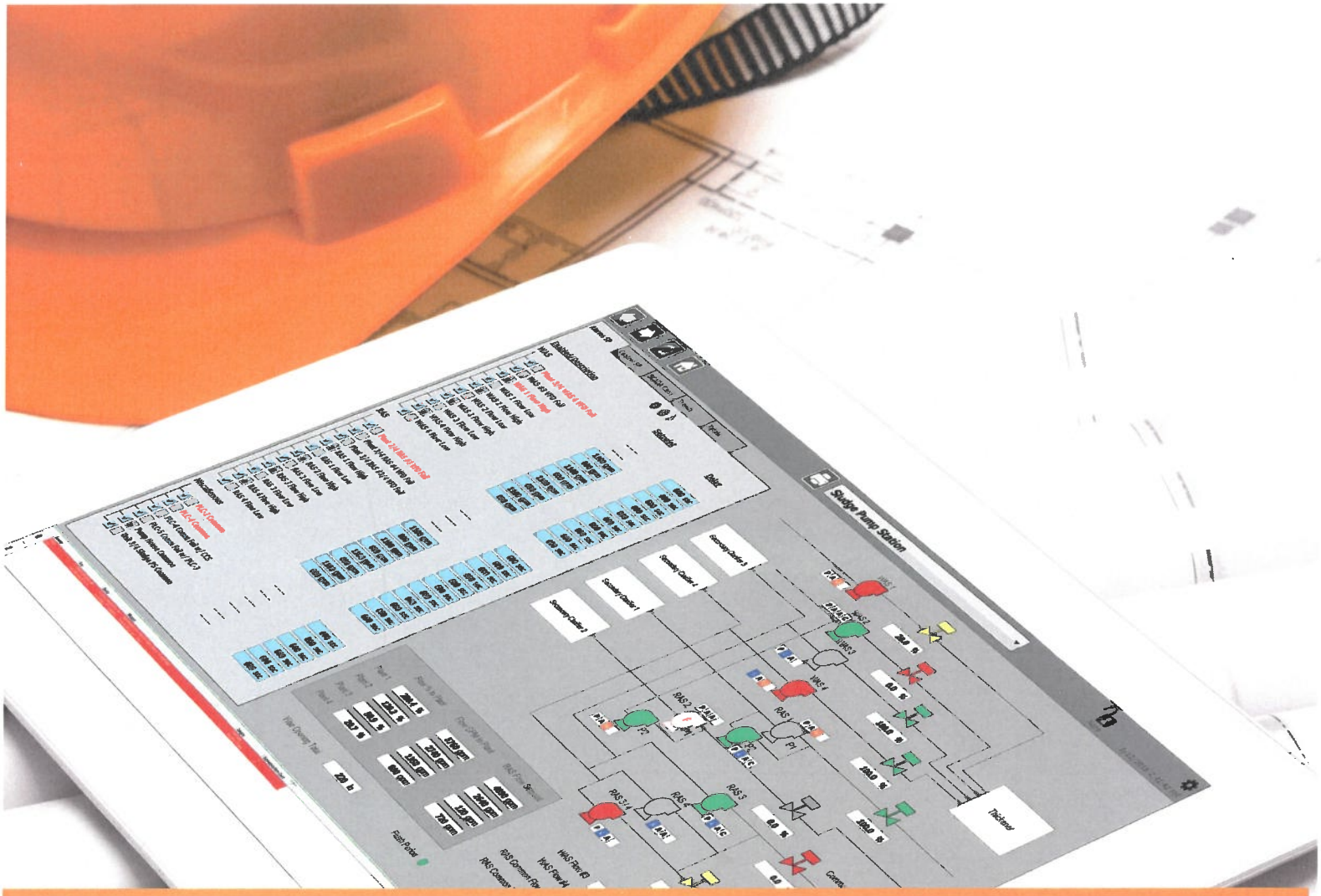
OPTION NO. 2—EXEMPTION

Pursuant to Public Contract Code Sections 2203(c) and (d), a public entity may permit a person/financial institution engaged in investment activities in Iran, on a case-by-case basis, to be eligible for, or to bid on, submit a proposal for, or enter into or renew, a contract for goods and services.

If you have obtained an exemption from the certification requirement under the Iran Contracting Act, please fill out the information below, and attach documentation demonstrating the exemption approval.

Name of Person (Vendor, Firm, Corporation, etc.)/Financial Institution (Printed):	Federal ID No. (or n/a):
By (Authorized Signature):	
Printed Name and Title of Person Signing:	
Date Executed:	Executed in (City & State):

VALLEY WATER



System Integrator Qualifications

Anderson Dam Tunnel Project

Project No. 91864005 | Contract No. C0663 | March 22, 2020

TESCO CONTROLS, INC.

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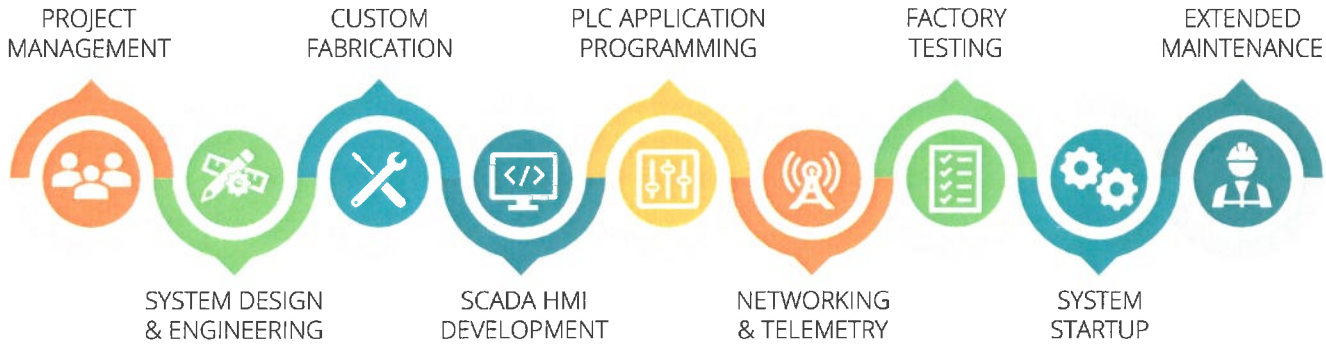
SYSTEM INTEGRATOR QUALIFICATIONS AND CAPABILITIES

Firm Information

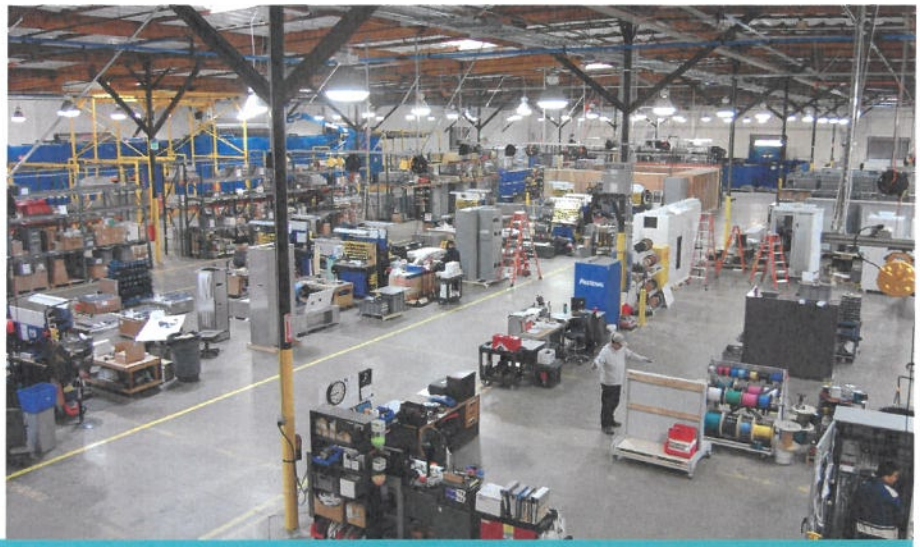
Tesco Controls, Inc. (TESCO) is a full-service, Level One CSIA-certified Systems Integrator and OEM for power components with 48 years of experience specializing in the design and implementation of control solutions required to automate water/wastewater treatment systems and related processes throughout the U.S.



OEM For Equipment Providers: TESCO is an original equipment manufacturer (OEM) for most major equipment suppliers, including Schneider Electric, allowing TESCO to integrate and support the complement of hardware and software deployed in control systems.

TESCO's fully-equipped manufacturing center is capable of engineering, fabricating, assembling, wiring, and testing all electrical and control systems equipment for project implementation and support.

Custom Fabrication: Many projects require custom solutions that are not readily available through standard equipment manufacturers.



TESCO's 125,000 square foot, UL-listed manufacturing and production facilities are located at our Sacramento headquarters.

Whether space constraints require custom enclosures, add-ons are needed for original equipment, or standard delivery schedules will not meet project deadlines, TESCO has full in-house fabrication facilities to expedite equipment builds for project delivery needs.

All products are manufactured in accordance with UL, IEEE, NEMA, IEC, NEC and CSIA requirements.

Contents

Water/Wastewater System Experts

TESCO's engineers specialize in building new and upgraded systems for large treatment plants, complex distribution and collection networks, and small improvement projects.

Unlike typical process control installations, water/wastewater designs and deployments must consider telemetry, advanced communications, regulatory compliance, and security, as well as the vital role control systems play in ensuring public health and safety.

Our subject matter experts understand the unique requirements and the challenges that industrial control system automation projects present in expediting project start-up and effectively collaborating to identify, design, and implement custom project solutions. We deliver projects involving treatment facilities, collection systems, distribution systems, pipelines, tanks and reservoirs, wells, pump stations, pressure reducing stations, lift stations, energy conservation, and renewable energy.

TESCO's in-house team includes engineering professionals with professional designations and certifications (PE and PMP):

- Electrical engineers
- Instrumentation and Control System engineers
- Power System engineers
- Computer, Systems, and Software engineers
- Communications and Networking engineers
- PLC and SCADA-HMI programmers
- Field Service engineers and technicians

TESCO's Capabilities and Resources: With a bench of 400+ employee-owners focused exclusively in the water/wastewater industry, our in-house resources include highly-skilled electrical and control system engineers, seasoned PLC programmers, SCADA engineers, field service engineers, and an experienced project management team that excels in the delivery of SCADA system solutions. Since 1972, TESCO has:

- Completed over 50,000 projects,
- Implemented over 400 SCADA systems,
- Managed 965 SCADA maintenance contracts, and
- Successfully delivered projects for over 4,300 different water/wastewater agencies.

Our reputation is based upon providing high-quality, end-to-end services – from project management and front-end engineering to field cut-over and commissioning.

Our services ensure continuity from initial planning to final commissioning so we can deliver projects on time, on target, and on budget.

Engineering: TESCO employs a diversified staff of qualified electrical, communications, and control system engineers. Our engineers are uniquely specialized in fields related to industrial electrical, instrumentation and controls, communications, and process control systems. We are capable of providing all the services necessary to design, implement, and support systems from inception to operation.

- Instrumentation and control systems
- Electrical switchgear (UL-891)
- Network infrastructure and cybersecurity
- Radio/telemetry systems
- Power distribution systems design and analysis
- Electrical motor control equipment (UL-845)
- Industrial control panels (UL-508A & UL-698A)
- Arc Flash risk assessment and mitigation

Project Management: TESCO's Project Managers guide our multi-disciplinary teams in achieving all project goals and objectives, while honoring the preconceived project constraints – including scope, resources, time schedule, and budget.

As required, Project Management Professionals (PMP) coordinate TESCO's scope of work, as well as become involved with the overall project collaboration, coordinating with the owner, consultant, general contractor, subcontractors, and other vendor/system suppliers to ensure the requirements for project integration are met.

Employing PMP Certified Project Managers ensures the discipline of planning, organizing, and managing resources while addressing the successful completion of project specific goals and objectives.

TESCO CONTROLS, INC.

Networking: Well-engineered network infra-structure is a critical requirement for reliable water/wastewater SCADA and process control systems. TESCO can help design, implement, and maintain network infrastructure to provide secure, robust, and fault-tolerant system architectures.

- Radio system engineering, path studies, and FCC licensing
- Data center equipment and rack design
- Backup power and cooling design
- Switching and routing
- Firewall implementation
- Network segmentation
- Network security design and industrial cybersecurity vulnerability mitigation
- Wide area private and public networks
- Fiber optic and copper-based designs
- WAN/LAN configuration

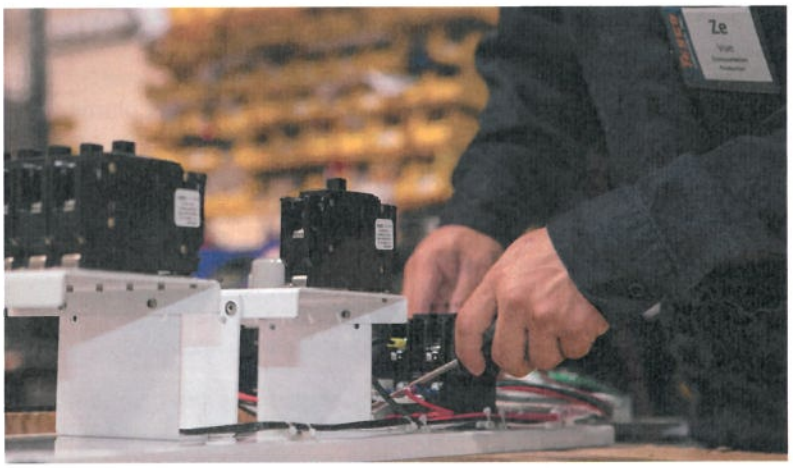
SCADA-HMI: TESCO is a leading provider of SCADA-HMI systems. We install SCADA systems nation-wide, and are certified in all major SCADA-HMI software packages.

Our team collaborates during the design phase to deliver feature-rich, field-proven SCADA-HMI programs to ensure reliable, robust and flexible control systems that fully meet the requirements of the project.

- SCADA-HMI application development
- System standards development
- Customized process displays
- Cybersecurity remediation
- Virtualized systems
- DCS and SCADA migrations
- Data backup and disaster recovery systems

Assessments: Designed to help water agencies address concerns about the reliability and sustainability of their process control systems, TESCO works collaboratively with the client to collect and document information related to their process control system automation technologies. An independent review and detailed analysis of findings is presented.

- SCADA-HMI and PLC application software backups
- SCADA and process control system (PCS) block diagrams



- Automation asset inventory spreadsheets
- Complete listing of IP networks, subnetworks, VLANs, and IP devices present in the system
- Technical report that incorporates findings, observations, and prioritized recommendations for key areas of improvement

PLC Programming: TESCO employs programming methodologies, both custom and templated, designed specifically for the water and wastewater industries. We leverage available technologies coupled with proven methods for software, communications, and hardware integration. Our team can upgrade aging systems while keeping critical plant processes online during the renovation.

TESCO programs many devices: PLCs, OITs, web servers, power monitors, and auto dialers.

Commissioning: TESCO uses a standardized approach to commissioning systems to confirm that the system performs as expected and per project requirements. Standard methods and procedures for system commissioning include: defined in phases, including:

- Factory testing
- Site testing / operational readiness testing
- Start-up / functional acceptance testing
- Switchover, commissioning
- Performance acceptance testing
- Operational and maintenance training

Custom fabrication options give clients the freedom to design solutions tailored to their needs, aesthetic, budget, and schedule.

Panel Fabrication & Staging Facilities

Our 125,000 square foot, Sacramento Headquarters and UL-Listed Manufacturing Facility, located only 90 miles away from San Francisco, facilitates agile project delivery and thorough factory testing. This fully-equipped manufacturing facility, complimented by our nearby field service and engineering offices in San Francisco and Salinas, includes a complete metal fabrication shop, powder coating paint line, wiring and assembly departments, and a dedicated factory staging and test lab. TESCO's control panels, service pedestals, and power distribution gear is manufactured in this facility, including anything we manufacture or modify acting as an OEM on behalf of Rockwell Automation.

MANUFACTURING SERVICES

TESCO manufactures at least 50 percent of the specified system in-house. Our fully-equipped manufacturing center is capable of fabricating, assembling, wiring, and testing all electrical and control systems equipment for project implementation. Our expertise in this area lends perfectly to designing and engineering all aspects of electrical distribution and control system requirements, as well as providing required equipment for turn-key, integrated solutions. **TESCO will self-perform and/or manufacture/ assemble more than 50% equipment in-house for the Valley Water Anderson Dam Tunnel Project.**

TESCO is an authorized Underwriters Laboratory (UL) manufacturer of electrical power and industrial control systems. TESCO systems are manufactured in accordance with UL, IEEE, NEMA, IEC, and NEC requirements. All assemblies adhere to strict manufacturing guidelines and quality control procedures. All phases of the manufacturing life cycle undergo an established quality control procedure to ensure the highest quality system.

TESCO CONTROLS, INC.

TESCO incorporates the LEAN® manufacturing model in our quality control process.

TESCO's manufacturing capabilities include:

- Custom enclosures (painted galvanized steel, 316SS, 304SS, aluminum, anodized aluminum)
- Electronic assemblies (programmable controllers, instrumentation, communications)
- Custom motor control systems
- Custom and standard power distribution systems
- Custom and standard pump station power distribution and control enclosures
- Electrical, hydraulic and pneumatic instrumentation control panels

FABRICATION

CUSTOM ENCLOSURES

- (Painted Galvanized Steel, 316SS, 304SS, Aluminum, Anodized Aluminum)
- Custom enclosures manufactured in accordance with NEMA standards in variety of styles and configurations. TESCO's enclosures and paint process meet State of California Department of Transportation (Caltrans) strict traffic enclosure test requirements for vandalism, glare, and salt spray duration testing.

ELECTRONIC ASSEMBLIES (PROGRAMMABLE CONTROLLERS, INSTRUMENTATION, COMMUNICATIONS)

TESCO-manufactured electronic assemblies (PLC, RTU, communications, instrumentation, etc.) are designed to withstand harsh industrial environments. These assemblies undergo temperature testing to 200 degrees F.

CUSTOM MOTOR CONTROL SYSTEMS

As an OEM, TESCO manufactures low-voltage (600V and below) motor control centers (MCCs) that include both indoor and outdoor applications. We have UL file extensions for major MCC manufacturers and can customize their standard product offerings.

Integrated motor controls can include solid state controllers, electro-mechanical starters, variable frequency drives, reduced voltage solid start starters, panelboards, PLC control sections, and communication packages.

CUSTOM AND STANDARD POWER DISTRIBUTION SYSTEMS

TESCO is UL authorized to manufacture distribution switchgear to 4000 A. All distribution and service pedestals are designed in accordance with utility system requirements. TESCO provides a variety of switchgear configurations employing auto-transfer switches, power monitoring and control, and feeder distribution.

CUSTOM AND STANDARD PUMP STATION POWER DISTRIBUTION AND CONTROL ENCLOSURES

TESCO provides a variety of standardized pump control packages for storm water, sewage lift, well pump, and booster stations. All pump stations can be supplied in low profile metered or unmetered enclosures systems.

ELECTRICAL, HYDRAULIC AND PNEUMATIC INSTRUMENTATION CONTROL PANELS

As an OEM, TESCO manufactures a variety of electrical, hydraulic, and pneumatic instrumentation and control panels.

COLORS AND COATINGS

All enclosures are prepared and powder coated in-house in an array of standard RAL color finishes. We also offer custom colors and anti-graffiti coatings, which are available upon request.

WARRANTY POLICY

TESCO-provided equipment is warranted against defect in design, workmanship and materials for a period of one year from the date of installation, unless otherwise specified.

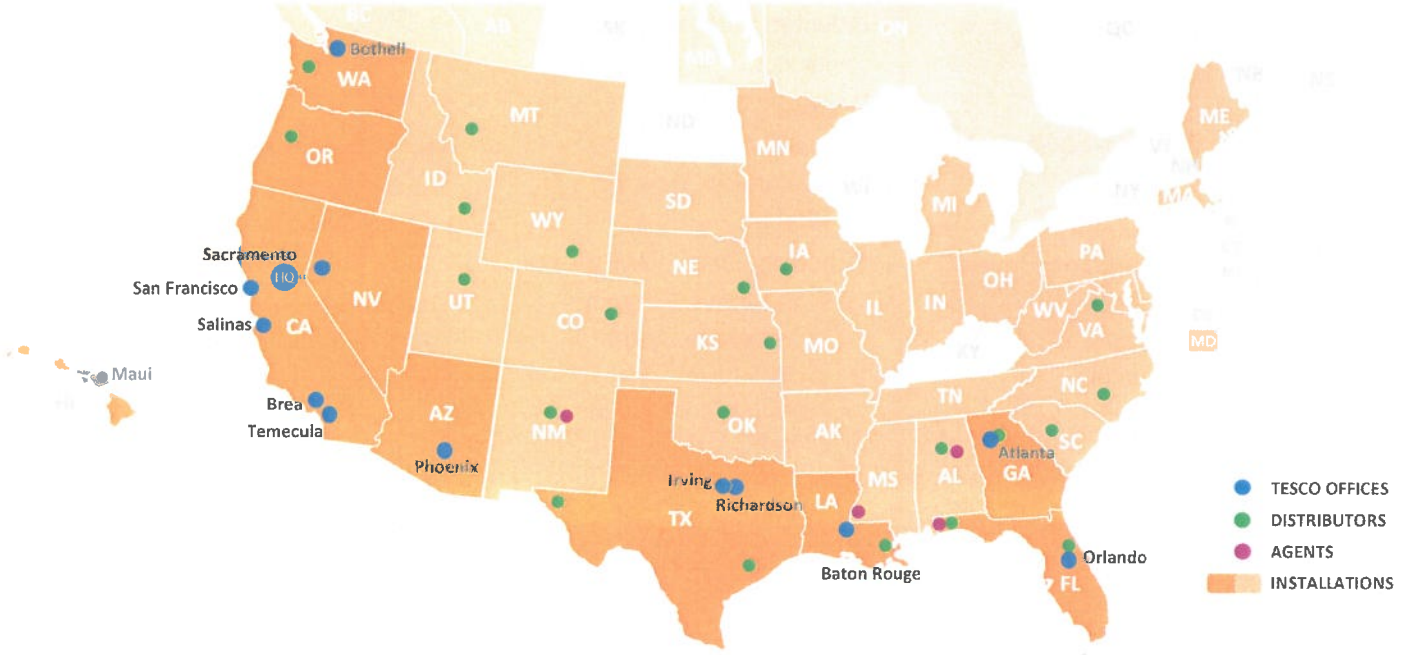
INDEPENDENCE FROM LITIGATION

TESCO is not involved in any current or pending litigation, claims, or legal dispute with any owner agency or municipality.

Locations & Contact Information

Sacramento, California houses TESCO's corporate headquarters and main manufacturing facility. To better serve our clients, we have opened offices and service centers throughout the United States, including California's central coast, bay area, and Southern California, the Northwest, Southwest and Southeast. The company plans to expand into Texas in the near future.

We value our commitment to provide responsive customer service to our clients across the country. Our offices and service centers are staffed with a variety of disciplines including electrical engineers, communication engineers, software engineers, field service engineers, service technicians, and business development professionals – all focused on our regional customers and their unique needs.



TESCO OFFICES

Corporate Headquarters & Manufacturing Center
8440 Florin Road
Sacramento, CA 95828
916.395.8800

Southern California
42015 Remington Avenue
Suite 102
Temecula, CA 92590
951.308.6450

Central California
1315-B Dayton Street
Salinas, CA 93901
800.948.3726

Bay Area California
600 California Street
11th Floor
San Francisco, CA 94108
800.948.3726

Nevada
213 Sage Street, Unit 3
Carson City, NV 89706
800.948.3726

Oregon
5250 High Banks Road
Suite 440
Springfield, OR 97477
800.948.3726

Washington
20250 144th Avenue NE
Woodinville, WA 98072
800.948.3726

Louisiana
4467 Bluebonnet Boulevard
Suite B
Baton Rouge, LA 70809
800.948.3726

Georgia
800 Battery Avenue SE
Suite 100
Atlanta, GA 30339
800.948.3726

Arizona
2 N. Central Avenue
Suite 1800
Phoenix, AZ 85004
800.948.3726

Dallas-Area Office & Manufacturing Center
8000 Jetstar Road
Suite 150
Irving TX, 75063
817.343.7163

Trimax Systems Inc.
565 Explorer Street
Brea, CA 92821
714.255.8590

Trimax Systems Inc.
1221 Abrams Road
Suite 327
Richardson, TX 75081
714.255.8590

TESCO CONTROLS, INC.

TESCO's Current Certifications

SYSTEMS INTEGRATION/ MANUFACTURING

- ABB Authorized Value Provider
- Control System Integrators Association (CSIA) Certified Level 1
- Rockwell Automation Solutions Partner
- Schneider Certified Alliance System Integrator
- Schneider Electric Square D Electrical Equipment Manufacturing Partner
- Siemens Solution Partner

CONTROL SYSTEM/ PLC PLATFORMS

- Rockwell Automation
  - » Allen-Bradley
  - » Studio 5000
  - » RSLogix
- Schneider Electric/AVEVA
  - » Modicon
  - » SCADAPack
  - » Unity PRO
  - » Concept
  - » ProWorx 32/NxT
  - » TelePace
- Siemens
  - » TIA Portal, STEP 7

UNDERWRITER'S LABORATORY

- UL-891 Electrical Switchgear
- UL-508A Industrial Control Panels
- UL-698A Industrial Control Panels
- UL-845 Motor Control Centers Extensions

SCADA-HMI /DCS PLATFORMS

- ABB
  - » Symphony
- GE
  - » Proficy iFIX
  - » Proficy iHistorian
- Inductive Automation
  - » Ignition
- Rockwell Automation
  - » PlantPAx
  - » FactoryTalk View SE
  - » RSView
- Schneider Electric/AVEVA
  - » Wonderware InTouch
  - » Wonderware System Platform
  - » Wonderware Historian
  - » ClearSCADA
- Siemens
  - » WinCC OA
  - » WinCC v7x
  - » WinCC Pro
- Trihedral
  - » VTScada
- Other
  - » Canary Labs Axiom
  - » Canary Enterprise Historian
  - » Specter Instruments – Win-911
  - » TopView Alarming

CONTRACTOR'S STATE LICENSING

- C-10 Electrical—California State Contractor's License

DESIGN-BUILD INSTITUTE OF AMERICA

- DBIA Member

REGISTERED PROFESSIONAL ENGINEERS (PE)

- Control Systems (CS)
- Electrical Engineering (EE)
- Mechanical Engineering (ME)

PROJECT MANAGEMENT

- Project Management Professional (PMP)

NETWORKING AND INFRASTRUCTURE

- Cisco Certified
  - » CCDA
  - » CCNP
  - » CCNA
- VMWare Certified
- Microsoft Certified

FIELD SERVICE

- ISA Certified Technicians

MISCELLANEOUS

- NEMA Compliant
- EUSERC Compliant
- IEEE IAS and IEEE 1584
- GSA Approved

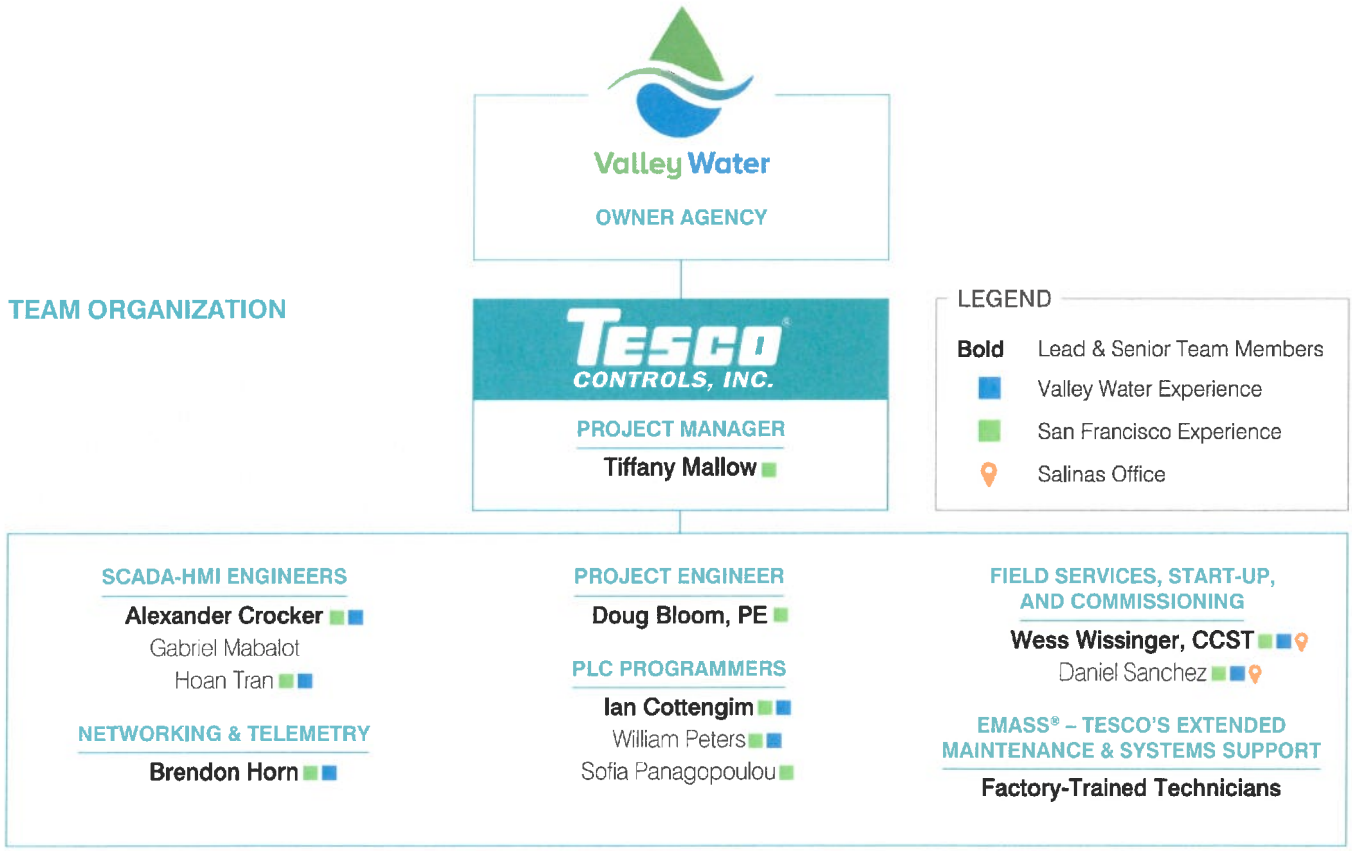
Originally UL-authorized in the 1970's, our most recent UL certification was granted in 2015.

TEAM QUALIFICATIONS

Firm Staffing & Key Personnel

TESCO has assembled the team shown in the following Organization Chart based on their relevant qualifications and experience to serve as TESCO's Key Personnel for Valley Water's Anderson Dam Tunnel Project. Our Key Team Members – many of whom have **Valley Water experience** as well as projects requiring adherance to the City and County of **San Francisco electrical code provisions and standards** – are listed below and summarized in a team experience matrix on the next page, followed by focused resumes highlighting individual qualifications and relevant experience.

TEAM ORGANIZATION



"We have been working with Tesco Controls, Inc., for over twenty years, both as subs through contractors and directly on many in-house projects. We have found the employees to be both knowledgeable and courteous and the overall company pleasant to work with. I would recommend their team on any project."

—Mr. Robert E. Motley III, Plant Maintenance, Electrical, and Instrumentation Supervisor, Mammoth Community Water District

TESCO'S KEY PERSONNEL EXPERIENCE MATRIX

NAME / ROLE ON TOWN PROJECTS	TESCO TITLE	RELEVANT EXPERIENCE: VALLEY WATER PROJECTS	RELEVANT EXPERIENCE: SAN FRANCISCO	YEARS AT TESCO	TOTAL YEARS
KEY TEAM MEMBERS					
Tiffany Mallow Project Manager	Project Manager		■	2.5	16.5
Doug Bloom, PE Project Engineer	Lead Production Engineer, Electrical & Control Systems		■	12	28
Wess Wissinger, CCST Lead Field Services, Start-Up & Commissioning	Central California Field Service Engineer & Supervisor	■	■	10	17
Alexander Crocker Lead SCADA-HMI Engineer	SCADA Engineer	■	■	8	12
Daniel Sanchez Field Services, Start-Up & Commissioning	Field Services Technician	■	■	7	18
Brendon Horn Networking & Telemetry Lead	Network & Telemetry Manager	■	■	17	24
Ian Cottengim Lead PLC Programmer	PLC Applications Engineer II	■	■	4.5	4.5
Gabriel Mabalot SCADA-HMI Engineer	SCADA Engineering Supervisor			4	5
Hoan Tran SCADA-HMI Engineer	SCADA Systems Engineer II	■	■	7	7
William Peters PLC Programmer	PLC Programmer	■	■	2	12
Sofia Panagopoulou PLC Programmer	PLC Applications Engineer I		■	<1	4

CAPACITY TO PROVIDE ADDITIONAL PERSONNEL

This team is supported by TESCO's unmatched in-house resources for professional engineering services, manufacturing and production, design and programming, wiring and testing, installation and commissioning, plus field services for scheduled maintenance as well as on-call troubleshooting and emergency services.

TESCO's in-house capabilities and certifications are summarized in Section 1.

EMASS® – TESCO'S EXTENDED MAINTENANCE & SYSTEMS SUPPORT SERVICES

Proactive Protection for Your Critical Systems by Factory-Trained Technicians: EMASS protects your critical systems by providing quality services support, detecting underlying problems, and assessing ongoing operational and upkeep needs.

TESCO offers a broad array of low-cost, high-value system support with professional and technical services that help extend overall system life, reduce out-of-service time, and provide you with protection against escalating costs. Our EMASS services allow you to plan and control your future service expenses. Our ISA-certified service engineers can service instrumentation and control equipment by any manufacturer.

TESCO's EMASS team becomes an extension of your staff in meeting your regulatory and reporting requirements as we assess, verify, calibrate, and maintain your water/wastewater instrumentation and control system applications.

16.5 Years of Experience
2.5 Years at TESCO

SPECIALIZED EXPERTISE

Delivering Systems Integration Projects for Water/Wastewater Treatment Facilities

EDUCATION

B.S., Business Administration, Devry University, Sacramento, California

Tiffany Mallow

PROJECT MANAGER

Tiffany Mallow is an effective leader with more than 16 years of experience managing technical projects, primarily focused on control systems integration for water and wastewater treatment facilities and associated infrastructure since joining TESCO. Her professional experience includes managing projects involving the planning, design, construction, and implementation of complex controls systems for managing utilities in municipal, governmental, industrial, commercial, and other business sectors. Tiffany brings experience managing complex, multi-phase projects that require extensive planning and coordination with the client and a variety of project stakeholders, including design consultants, vendors, general contractors, subcontractors, program managers, and regulatory agencies.

Tiffany's focus on understanding the needs and goals of each client strengthens her ability to effectively manage complex projects that construct new and upgraded control systems for municipal water and wastewater treatment, collection, storage, and distribution facilities.

In addition to her experience managning projects for the City and County of San Francisco, Tiffany's strengths include proactive, effective communication and documentation to track project decisions, manage personnel, negotiate and implement contracts, respond to Requests for Information and Change Orders, facilitate construction meetings, and keep project momentum to remain on-schedule and within budget. Some of her recent and current projects are summarized below.

RELEVANT EXPERIENCE

Yerba Buena Island Sub-Phase 1Y & 1YB Sanitary Sewer Pump Stations, City and County of San Francisco, CA: Project Manager

Part of a major four-phase project to construct new residential development, this project constructs all new wet and dry utilities, including two new sewer pump stations at North Gate Road and Macalla Road on Yerba Buena Island. TESCO engineers developed interconnection wiring diagrams and prepared seismic calculations, and our in-house fabrication and manufacturing team provided assembly, wiring, and witnessed factory testing for new motor control center (MCC) pedestals for the two pump stations. TESCO provided PLC programming for Modicon M340, OIT programming for Modicon Magelis, and configuration of two Ethernet switches and firewalls; SCADA programming was performed by City staff. Field services included installation, integration, testing, and start-up services. TESCO also provided City staff training on the new MCCs, ATS, and PLC control system, and provided detailed O&M manuals.

Treasure Island Sub-Phase 1B, 1C & 1E, City and County of San Francisco, CA: Project Manager

This project is part of a major four-phase project that constructs new residential development, including all new water distribution and sewer collection systems, storm drainage, and dry utilities, on Treasure and Yerba Buena Islands in San Francisco Bay. TESCO provided PLC and OIT programming for the new Modicon M340 and Magelis PLCs, and provided and configured the new Ethernet switch and firewall for two new Sanitary Sewer Pump Stations at 4th Street and 5th Street, and two new stormwater treatment systems at Cityside Park and at the Clipper Cove/Avenue C intersection. TESCO engineers developed interconnection wiring diagrams and performed seismic

calculations, our in-house shop staff manufactured and assembled the associated MCCs and pedestals, including all wiring, power supplies, and instrumentation. TESCO provided equipment, in-house witnessed factory testing, and on-site start-up services. This project also included staff training for the new MCCs, ATS, and control system.

Yerba Buena Island Potable Water Tank & Pump Station Improvements, City and County of San Francisco, CA: Project Manager

To supply a new residential neighborhood on a small island with challenging topography and seismic design considerations, this project constructed all new wet and dry utilities, including a new water storage tank and pump station, with associated piping, drainage, and transmission main. TESCO provided PLC programming for the new Modicon Quantum, and network coordination for the new tank and pump controls. TESCO manufactured and assembled the new MCC, conducted witnessed factory testing, and provided and installed transmitter and switch instrumentation, and provided an IP router and dish antenna to be installed by others. Start-up services included installation verification, programming adjustments, and configuration, and TESCO subsequently provided City staff training on the new MCCs, automatic transfer switch, and instrumentation and controls.

UN Plaza Water Storage and Distribution, City and County of San Francisco, CA: Project Manager

This project restores water reuse operations to supply non-potable water for municipal and agricultural use as well as for the UN Plaza Fountain. TESCO furnished and installed enclosures, motor control centers (MCCs), control system software and hardware, and various instrumentation and provided design, testing, and integration services for a new/upgraded Wonderware SCADA system. The new/upgraded system includes InTouch Panel HMI, MODBUS PLCs, Ethernet switch, server, and field services for start-up and commissioning. TESCO supplied and installed additional power distribution blocks for the Pure Aqua System feed, and provided on-site installation and system configuration services. TESCO also provided training for Public Works Staff, plus detailed O&M manuals with product information.

Secondary Treatment Plant Upgrade, Las Gallinas Valley Sanitary District, San Rafael, CA: Project Manager

This $64 million project replaced aging equipment to comply with discharge regulations and to modernize operational efficiency by expanding and upgrading an existing treatment plant. TESCO manufactured and furnished new control panels with PLCs, variable frequency drives (VFDs), motor control centers (MCCs), switchboards, power supply, fiber optics, radio and network equipment, and instrumentation various treatment process facilities. Where possible, TESCO retrofitted existing control panels. TESCO commissioned all loops for multiple VFDs, dissolved oxygen analyzers, chlorine analyzers, turbidity analyzers, flow meters, and pressure transmitters. TESCO was on-site during start-up and also provided District staff training and detailed O&M manuals on the new equipment and instrumentation.

Advanced Facility Control & Meter Replacement Phase 1, City of San Jose, CA: Project Manager

As part of a larger $1.4 billion program to rebuild and modernize the 167 mgd San Jose-Santa Clara Regional Wastewater Facility (RWF), the City selected TESCO as the prime contractor for a $11.7 million design-build project to replace aging equipment, enhance process control, and comply with water quality and discharge regulations at an existing regional wastewater facility (RWF). The project installed drain plates in eight of 11 return activated sludge (RAS) meter vaults.

TESCO provided engineering, PLC programming, factory acceptance testing, start-up services, manufacturing, and field services. Tiffany managed the TESCO team and also coordinated all activities of subconsultant ABB, who provided DCS programming for this project. Phase 1 included design, programming, installation, testing, and integration of flow meters, process control valves and actuators, piping and supports, isolation valves, instrumentation, and associated infrastructure to maintain compliance with the RWF's National Pollutant Discharge Elimination System (NPDES) Permit. TESCO supplied and installed new control panels, magnetic flow meters ranging in size from 10 inches to 48 inches, instrumentation, and control panels. TESCO provided engineering design services, training for the City's operations and maintenance staff, O&M manuals, and a 10-year flow meter warranty.

Hexavalent Chromium Compliance Water System, City of Newman, CA: Project Manager

This project constructed a new 1 MG water storage tank, three new booster pumps, and associated water transmission and distribution main, to connect to the newly-drilled Well No. 10 and also tie into the City's water distribution system. Having designed and implemented the original system, TESCO was selected to implement upgrades to the existing Wonderware InTouch wastewater SCADA system, the L3000 PLCs in the distribution system, and Allen-Bradley MicroLogix PLCs for the sewer collection system, in addition to integrating the controls for new water facilities at 16 different sites. Software upgrades included new VMWare ESXi6 Hypervisor, System Platform, InTouch, MS Office Professional, MS Server, and Win-911.

28 Years of Experience
12 Years at TESCO

SPECIALIZATION

Engineering Design for Power, Instrumentation, and Controls

EDUCATION

B.S., Aeronautical Engineering, Embry Riddle Aeronautical University, Prescott, Arizona

REGISTRATIONS

Professional Electrical Engineer:

- California No. 19039
- Hawaii No. 14551

PROFESSIONAL AFFILIATIONS

American Water Works Association (AWWA)

FIELDS OF SPECIAL COMPETENCE

PLCs, OITs, HMI, Instrumentation

Pump and motor centers: MCCs, Soft Starters, Starters, Variable Frequency Drives (VFD), harmonics

Power distribution, service entrance equipment, switchboards, switchgear, transfer switches, solar power, UPS/battery sizing

Continued on the next page

Doug Bloom, PE

LEAD PRODUCTION ENGINEER, ELECTRICAL & CONTROL SYSTEMS

Doug Bloom is a registered electrical engineer with 28 years of experience specializing in power, automation, motor controls, electrical gear, and systems integration for water and wastewater treatment systems and associated infrastructure. He manages TESCO's engineering team in providing automation assessments and design services for the development and implementation of the power and control systems required to effectively manage processes for water treatment plants, booster pump stations, water storage tanks and reservoirs, well sites, lift stations, and wastewater treatment systems.

Doug leads TESCO's engineers in evaluating existing systems, developing plan drawings and system configuration/ specifications, and collaborating with our multi-disciplinary technical and production teams to deliver successful projects.

Doug brings hands-on experience in system evaluation, design, and coordination; hardware and software specification; PLC/RTU application design and specification; instrumentation evaluation and specification, and design services. He specializes in Programmable Logic Controls (PLCs), Operator Interface Terminals (OITs), Human Machine Interface (HMI), communications, instrumentation, control panels, pump and motor controls, motor control centers (MCCs), harmonics, power distribution, service entrance equipment, switchboards, switchgear, transfer switches, solar power, and uninterruptable power supply (UPS) battery sizing.

RELEVANT EXPERIENCE

WW-639 Oceanside Water Pollution Control Plant (WPCP) Digester Gas Utilization Upgrades, San Francisco Public Utilities Commission (SFPUC), CA: Supervising Engineer

This challenging $30 million project replaced a deteriorating digester biogas internal combustion cogeneration system and required temporary process equipment be installed at the treatment plant in order to remain in continuous operation during the upgrades. TESCO supplied the temporary switchboard, panelboard, and automatic transfer switch before implementing programming modifications to the PLCs, configuring Ethernet switches, modifying the existing control panels, conducting witnessed factory testing, and installing new control panels, VFD panels, flow meters, pressure gauges and transmitters.

Water/Wastewater Control Design Standards, City of Morgan Hill, CA: Reviewing Engineer

After providing control system integration and support services for the City's water and sewer infrastructure for more than 29 projects over the prior 15 years, TESCO was selected to develop design and programming standards for all of the water storage tank sites, well sites, booster pump station sites, stormwater lift stations, and valve sites included in the City's Sewer Collections and Water Distribution Control System. In order to incorporate City staff preferences and system knowledge into the standards, TESCO conducted engineering workshops and included City feedback in the specifications. The project resulted in a comprehensive control standards package that the City's contracted consultants now use for capital improvement

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projects to provide continuity for controls and electrical control equipment specifications in future water distribution and sewer collection system design projects.

Communications: auto-dialers, fiber, modems, radios

Berkeley View Regulator Pump Station, East Bay Municipal Utility District (EBMUD), Berkeley and Orinda, CA: Project Engineer

The purpose of the project was to demolish and replace pumps, piping, electrical equipment, a regulator, crane and drain lines at the Berkeley View Pumping Plant; demolish and replace the pumps, piping, electrical equipment and pumping plant building at the Las Aromas Pumping Plant; and demolish and replace existing piping at the Madrone, Shapiro, and Skyline Pumping Plants.

TESCO was responsible for providing new switchboards, metering cabinets, Motor Control Centers (MCC), and panelboards. Additionally, TESCO fabricated, manufactured, and assembled new Freestanding NEMA 4X Stainless Steel Allen-Bradley equipped PLC Control Panels for the Berkeley View Pumping Plant and Las Aromas Pumping Plant. Doug coordinated Eaton's equipment design for switchboards, MCCs, and panelboards. Doug supplied and installed power monitors in switchboards and motor control centers, and designed control panels containing a master RTU with multiple PLCs used to control individual booster pumps. Doug also designed and coordinated the testing of the communication (DNP3, Ethernet, Modbus) between all devices.

Dingee Pipeline & Clairemont Aqueducts Replacement, East Bay Municipal Utility District (EBMUD), Oakland, CA: Project Engineer

This project replaced a 12,000 foot segment of the aging Dingee Backbone Pipeline, a primary transmission pipeline that delivers water to 18,000 customers in the central Oakland Hills. The project also replaced 2,900 feet of large-diameter aqueducts at EBMUD's Claremont Center near the Caldecott Tunnel, as well as smaller distribution mains in several adjacent streets. This work was necessary to reduce service disruptions and maintenance costs associated with leaking and deteriorating pipelines.

TESCO was responsible for fabricating, manufacturing, and assembling new Freestanding NEMA 12 Stainless Steel Instrument Control Panels and Wall-Mount NEMA 4X Stainless Steel Pump Station Local Control Panels Additionally, TESCO was responsible for providing modifications to existing Water Quality Control Cabinets. Doug worked with EBMUD and the manufacturer to select 4-inch magmeters suitable for chloramine service and direct burial that would also be available within the project time-frame. He also selected and designed other field instruments, an instrument panel, and two local control panels.

Shasta Park Water Facility, City of Sacramento, CA: Project Engineer

This $13 million project constructed a new 2 mgd water treatment plant, 15 mgd booster pump station, and 4 MG water storage reservoir within an existing 18-acre community park. TESCO provided engineering design services, SCADA programming modifications, PLC programming and a radio survey for the new controls. TESCO fabricated, manufactured, assembled, tested, installed, and installed the new MCCs, VFD control panels, network control panel with Ethernet, remote radio panel and microwave antenna, flow meters, switches, and transmitters. TESCO also provided services during start-up, on-site training for City staff, and detailed O&M manuals.

17 Years of Experience
10 Years at TESCO

SPECIALIZATION

Field Services for Troubleshooting and Repair of Instrumentation and Controls

FIELDS OF SPECIAL COMPETENCE

Implementation for Automated Control Systems, including:

- Motor controls
- PLC/RTU communications
- Instrumentation applications related to monitoring and control of water and wastewater control systems

EDUCATION

B.S., Industrial Technology with Minor in Manufacturing System Management (Robotics, Plastics, and CAD/CAM)

CERTIFICATIONS

International Society of Automation (ISA) Certified Control Systems Technician (CCST), Level 1

Certified PROFIBUS Installer

Siemens UltraSonic Level

Wess Wissinger, CCST

CENTRAL CALIFORNIA FIELD SERVICE ENGINEER & SUPERVISOR

Wess Wissinger is an ISA-certified Level 1 Certified Control Systems Technician (CCST) as well as a Journeyman Field Service Engineer. He has 17 years of experience providing start-up, calibration, and troubleshooting services for instrumentation, programmable logic controller (PLC), and variable frequency drive (VFD) projects at water and wastewater treatment plants and associated facilities.

Known for his dedication to providing accurate troubleshooting and delivering effective solutions to control system issues as they arise, Wess is focused on serving TESCO's clients in California's central coast region.

As a Field Service Engineer, Wess performs all on-site field engineering activities including testing, parameter configuration, startup testing, and training for automated control systems for industrial water and wastewater treatment facilities and associated infrastructure. He provides coordination with subcontractors, supervision for integration projects, calibration of instrumentation systems, and field support. Wess also provides services including on-site application design adaptations, control system modifications, programmable device adjustments, and other as-needed, on-site support services during the project start-up phase. He serves as the on-site main point-of-contact during each project phase, through completion.

RELEVANT EXPERIENCE

Fluoride Treatment Addition at Santa Teresa and Penitencia Water Treatment Plants, Valley Water, San Jose, CA: Field Service Engineer

This project involved the supply of new Allen-Bradley VFD control cabinets and tank valve control cabinets installed at the District's Santa Teresa and Penitencia Water Treatment Plants. TESCO provided all necessary SCADA and PLC programming. Wess was responsible for field testing, start-up, commissioning, and system training.

WD-2621R Groundwater Supply Well Stations, San Francisco Public Utilities Commission (SFPUC), CA: Field Service Engineer

This project involved integrating, configuring, and programming new Modicon Quantum and M340 PLCs in Unity. The PLCs were integrated with Operator Interface Terminals (OIT) and networked with multiple communication methods, including Ethernet, CSU/DSU telephone circuits, radio telemetry, and satellite communications. TESCO was responsible for loop and interconnection diagrams, arc flash risk assessment and coordination studies, and communication integration.

TESCO provided multiple days of training on the PLC software configuration, systems operations, and VFDs. Wess was responsible for the start-up of four new well sites and one reservoir. The new well sites include 350-amp turbine motors to produce 1-5 mgd with disinfection. Wess also helped tune the PIDs for dosing and well pump flow controls.

WW-628-02A Bruce Flynn Pump Station Improvements, San Francisco Public Utilities Commission (SFPUC), CA: Field Services Technician

This project replaces headworks at the Southeast Water Pollution Control Plant (SEWPCP) with a 250 mgd capacity all-weather facility under three primary scopes of work for 1) implementation of a flow re-route pipe to send wet weather flows

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around an existing headworks facility, 2) upgrades and general modifications within the existing Bruce Flynn Pump Station, and 3) construction of a new reinforced concrete headworks structure. The project replaced six 430HP submersible pumps and associated VFDs, two wet well dewatering pumps, and installed new electrical appurtenances, instrumentation sets, and control packages.

TESCO conducted a short-circuit and coordination study, performed an arc flash risk assessment, designed updates to panel and switchgear layouts, and designed wiring diagrams and relay settings. TESCO performed modifications on several pieces of medium-voltage equipment, requiring significant coordination and planning related to power outages while numerous contractors performed work simultaneously. TESCO also provided several new ABB VFDs and controllers, as well as new local control stations, instrumentation panels, control panels, and a PROFIBUS panel. Professional services included design-build engineering services, PLC and local HMI programming, network configuration, factory testing, and on-site product start-up and training services.

WWTP Immediate Action Phase 1, City of San Mateo, CA: Field Services Technician

This $5.6 million project involved replaced communication infrastructure by providing new MCCs, VFD panels, PLC control panels, and local control panels. TESCO innovated a custom solution for integrating Allen-Bradley PLC systems programmed with PlantPAx methodologies into an existing Wonderware SCADA application. TESCO investigated the existing infrastructure and documented all existing controls, wire sizes, and conduit sizes in addition to conducting multiple collaborative PLC Programming Workshops and System Configuration Meetings with City staff. As with existing operating plants, the switchover of the control panels without interrupting the process was crucial. TESCO also performed factory testing, field demonstration testing, and system training for City staff.

Gilroy WWTP East Generator Replacement & SCADA Network, South County Regional Wastewater Authority (SCRWA), Gilroy, CA: Field Service Engineer

This project involved upgrading existing Rockwell Automation Allen-Bradley SLC-series PLCs to new ControlLogix units utilizing the Allen-Bradley ControlLogix PLC Conversion Kits. Specifically, new ControlLogix-equipped Master Control Panels (MCPs) were provided and implemented with TESCO providing a conversion of process area I/O to Remote I/O (RIO) controlled by the MCP. TESCO provided modifications to the existing SCRWA control system components and was responsible for the overall systems integration for the project. The existing DataHighway+ network was converted to a new Ethernet network. TESCO also provided new networking gear, SCADA equipment, and low voltage motor control. Wess was responsible for removal of the existing Allen-Bradley PLC-5 systems to new CompactLogix PLCs and startup of the new blower system and return activated sludge (RAS) pump stations/clarifier.

One of TESCO's value-added solutions for SCRWA included delivering the SCADA hardware upgrade in a fully-virtualized environment. Project challenges included the need to communicate across DH+ and Ethernet networks simultaneously during transition and the heavy coordination associated with working in an operating, brownfield WWTP. Since completion of this project, TESCO has continued providing integration services for SCRWA for their WWTP projects, including the UV Disinfection Facility, Clarifier #3 Addition, and Oxidation Ditch Improvements projects.

ProWorx32 Programming Level 2

RSLogix 500 & RSLogix 5000

ABB Variable Frequency Drives

SPECIALIZED EQUIPMENT TRAINING

ABB Drive Systems

Telemecanique/Square D Variable Frequency Drives

Control Automation and Instrumentation Systems

SAFETY TRAINING

Fall Prevention

Confined Space

OSHA 10

12 Years of Experience
8 Years at TESCO

SPECIALIZATION

SCADA HMI for Water-Wastewater Systems

FIELDS OF SPECIAL COMPETENCE

Computer Systems / Software Applications Related to Monitoring and Control of Water and Wastewater SCADA Systems

EDUCATION

B.S., Electrical Engineering, University of California, Davis

CERTIFICATIONS

GE Proficy HMI / SCADA iFIX Advanced

NCEES Engineer-in-Training

Technologist Grade 2

Trihedral VTScada Advanced Configuration

SPECIAL TRAINING

GE Proficy iFIX

GE Proficy Historian

GE Proficy Machine Edition

Rockwell Automation RSLogix 500 & 5000

Windows Server and Terminal Services

Alexander Crocker

SCADA ENGINEER

As a SCADA Systems Programmer for TESCO, Alexander provides all of the site-specific software configuration applications for graphical user interfaces, reporting formats, historical data access, and process monitoring related to the specific operational characteristics of each SCADA system.

Alexander brings extensive iFix experience. He is known for establishing configurations for systems requiring a strong client interface, and for implementing system designs that provide data representation and access in a user-friendly environment.

Alexander has specific experience in software applications for centralized monitoring and control of water and wastewater SCADA systems for treatment process facilities and infrastructure for sewer collection, water storage and distribution, storm drainage, and groundwater systems. His industrial automation experience with design, programming, instrumentation configuration, implementation of controls for new and existing systems allows Alexander to identify and integrate complex municipal and industrial systems.

RELEVANT EXPERIENCE

Boyce Road Sewer Lift Station, Union Sanitary District, Fremont, CA:
SCADA Engineer

This project involved an expansion and modification of the Union Sanitary District's SCADA System. Alexander performed all SCADA work to bring the new lift station into the iFIX system, from design to functional testing. This includes I/O configuration, database development, and graphics and HMI design. In addition, specific scripting was required and implemented to integrate the new site into the existing communications diagnostic, safety, and navigation schemes in accordance with Union Sanitary District specifications and standards.

Anaerobic Digester No. 4 & Fog Receiving Facility, Dublin San Ramon Services District (DSRSD), Pleasanton, CA: SCADA Engineer

This $3.3 million project constructed a fourth anaerobic digester and fat/oil/grease (FOG) receiving station at the existing DSRSD Regional Wastewater Treatment Facility in Pleasanton. This new energy-efficient process allows the District to capture the biogas byproduct as renewable fuel used to generate electricity and heat for plant operations. TESCO provided SCADA programming upgrades to City's GE iFIX SCADA system and Allen Bradley CompactLogix PLCs, modified Ethernet connections, provided manufacturing services and witnessed factory testing, and implementation, start-up, and commissioning services. TESCO also provided staff training and detailed O&M manuals.

Mixed Liquor Replacement (MLR) Project, City of Brentwood, CA:
SCADA Engineer

For a project to reconfigure and upgrade an existing motor control center (MCC) for the mixed liquor treatment process, TESCO conducted an on-site review of the existing cabinets and PLCs before providing a new 30 hp variable-frequency drive (VFD) bucket and programming services for the City's SCADA system and PLCs. TESCO coordinated with the City's electrical contractor to provide and integrate six updated control panel cabinets and PLC panels during construction. TESCO also

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provided services during start-up and commissioning, and also provided staff training and detailed O&M manuals.

Ultrasonic Level Transmitter Installation and PLC/ SCADA Integration at the End of Boardman Canal, Placer County Water Agency (PCWA), Auburn, CA: SCADA Engineer

TESCO installed and integrated a new Siemens Ultrasonic Level Transmitter into an existing stilling well located at the end of PCWA's Boardman Canal. TESCO visited the site, reviewed the as-built documentation, documented the existing system, and tested the existing radio link and hardwire cabling before providing PLC and SCADA programming, configuration, and integration services to bring data transmitted from the Level Transmitter into the existing iFix SCADA system.

Alta Water Treatment Plant Phase 1 Improvements, Placer County Water Agency (PCWA), Auburn, CA: SCADA Engineer

The initial phase of an improvements project to update an existing water treatment plant, this project removed existing surface wash pump controls and backwash sequence functions and installed a new air scour blower control, air scour backwash and air/water backwash step sequence. TESCO provided system integration that included programming modifications to GE iFIX SCADA and Allen-Bradley PLCs, and including the existing Master PLC. TESCO implemented programming modifications to the backwash sequences to support the new air scour wash, air/water wash and a backwash feature that allows for a water-only backwash when the Air Scour System is bypassed. TESCO manufactured and provided new control panels, modified the existing remote input/output (RIO) configuration, provided on-site start-up and commissioning services, as well as staff training and detailed O&M manuals.

West Oaks Blvd. Pressure Reducing Station, Placer County Water Agency (PCWA), Auburn, CA: SCADA Engineer

This project upgrades an existing water distribution system pressure reducing station. TESCO programmed and integrated new Allen-Bradley MicroLogix PLCs with the iFix SCADA system that controls the pressure indicating transmitters. TESCO fabricated, manufactured, assembled, wired, and factory-tested new PLC control panels, provided and installed the Yagi Directional Antenna, and also provided field services for installation, integration, start-up, and commissioning. TESCO provided staff training and O&M manuals.

SCADA System Replacement, City of West Sacramento, CA: SCADA Engineer

Tesco performed a full replacement of the City of West Sacramento SCADA system. Their previously deployed Tesco SCADA system consisted of two separate RSView systems, one for the water treatment and distribution system and one for the sewer collections system; all of which has been consolidated into one cohesive networked SCADA system. Alexander configured all new hardware and software to integrate both of these existing systems into one new iFIX system consisting of two redundant SCADA servers using enhanced fail-over, a Proficy historian server, and a iFIX iClient Terminal Server for remote access. He fully converted both existing I/O databases into iFIX (totaling around 15,000 points),and created new iFIX graphics to retain all of functionality and features of the old system. The new WIN-911 autodialer call-out system was also installed and configured which improved the functionality of the system by providing redundant call-out.

SCADA System, City of Woodland, CA: SCADA Engineer

As the City's primary SCADA technician, Alexander was responsible for SCADA System development, expansions, modifications, enhancements, user support, user group policy deployment, and system maintenance. The system consisted of a pair of redundant iFIX SCADA servers using enhanced fail-over, a Proficy HISTORIAN server, and an iFIX iClient Terminal Server for remote access. Alexander was essential to the City's major SCADA system upgrade. He was responsible for computer equipment and hardware replacement, deployed software version upgrades, and consolidated all I/O into the IGS server/driver. He also provided process area additions to the system, including chemical treatment, flow control systems, and generator controllers. Additionally, Alexander provided critical coordination with an outside system supplier to tie-in approximately 20 water production well sites into the system.

Bowman Water Treatment Plant Sodium Hypochlorite, Placer County Water Agency (PCWA), Auburn, CA: SCADA Engineer

To comply with water quality regulations, this project installed a new sludge processing system and converted the disinfectant from chlorine gas to sodium hypochlorite at the existing 2 mgd Bowman Water Treatment Plant. TESCO provided SCADA and PLC programming including modifications to the Master PLC, the existing WAN, and existing control panels at the equalization basin, PLCs, alarms, and other process facilities. TESCO also supplied and calibrated the instrumentation, and provided on-site start-up services and staff training.

18 Years of Experience
7 Years at TESCO

SPECIALIZATION

Instrumentation and Controls

FIELDS OF SPECIAL COMPETENCE

Implementation of Control system automation including:

- Motor controls
- PLC/RTU communications
- Instrumentation applications related to monitoring and control of water and wastewater control systems

EDUCATION

Los Angeles Trade Tech, Los Angeles, California

CERTIFICATIONS

General Journeyman Electrician State Certification

Daniel Sanchez

FIELD SERVICE ENGINEER

Daniel Sanchez is Field Service Specialist who performs a variety of field activities including testing, parameter configurations, start-up, and staff training for automated control systems and associated components for municipal water and wastewater systems. He performs on-site application design adaptations, control system modifications, and programmable device adjustments. He is present to support the project start-up phase, and serves as the on-site point-of-contact during each phase of the project.

Daniel brings extensive experience with the modification, start-up, and support of numerous industrial control system projects, including nearly all types of instrumentation utilized in the water and wastewater industry.

Daniel is responsible for field project coordination, implementation of communication systems, instrumentation systems commissioning, site startup, and troubleshooting for industrial/electrical control systems, radio systems, Variable Frequency Drives (VFDs), and facilitating plant-wide instructional training programs. His field engineering duties include coordinating with subcontractors, supervising integration needs, calibrating instrumentation systems, and providing field support.

RELEVANT EXPERIENCE

WD-2686 AWSS Pumping Stations No. 1 Improvements, San Francisco Public Utilities Commission (SFPUC), CA: Field Service Engineer

The WD-2686 AWSS Pumping Station No. 1 Improvements project involved the manufacture and supply of new Motor Control Centers and RTU panels as well as the supply of instrumentation including, but not necessarily limited to, level transmitters and switches, pressure transmitters, temperature transmitters, air flow switches, flow switches / flow paddle switches, and flow meters. TESCO was further responsible for PLC and OIT programming services, engineered technical packages, personnel training, and startup of the system. Daniel' duties included installation verification, power-up testing, control implementation, start-up, and commissioning.

Fixed Gas Monitoring System Upgrades, San Francisco Public Utilities Commission (SFPUC), CA: Field Service Engineer

The Fixed Gas Monitoring System Upgrades Project involved the manufacture and supply of new Human Machine Interface (HMI) panels, gas monitoring panels, and Uninterruptable Power Supply (UPS) panels. Additionally, TESCO provided fiber optic patch panels, alarm strobe lights, and alarm horns in addition to PLC/ HMI programming professional services. Daniel was responsible for installation verification, power-up testing, equipment jogging, loop check verification, PID loop control implementation, start-up, and commissioning.

Wastewater Treatment Facility Phase V Solids Handling Upgrade, San Francisco Public Utilities Commission (SFPUC), Sunol, CA: Field Service Engineer

Located in Alameda county, the Town of Sunol Fire Suppression System Project involved the manufacture and supply of new level transmitter display enclosures with custom glass windows. TESCO supplied instrumentation including, but not necessarily limited to, submersible level transmitters and float switches. TESCO also provided engineered technical documentation, including as-built P&ID's, as-built interconnection

diagrams, and O&M manuals. Daniel was involved in the field testing, field calibrations, startup, commissioning, and operator training for the system.

Malaga Wastewater Treatment Plant Improvements, Malaga County Water District, Fresno, CA: Field Service Engineer

For this project, TESCO manufactured and supplied new turbidity meters and transmitters as well as modifications to existing turbidity control panels. TESCO furnished and integrated new MCC buckets, flow meters with Doppler ultrasonic velocity sensors, and PLC I/O racks. TESCO also provided PLC programming, HMI programming, and SCADA integration services. Daniel provided physical and mechanical visual inspections, electrical connection verifications, loop tuning, function testing, and on-site staff training on the new system.

Gilroy WWTP East Generator Replacement & SCADA Network, South County Regional Wastewater Authority (SCRWA), Gilroy, CA: Field Service Engineer

This project involved upgrading existing Rockwell Automation Allen-Bradley SLC-series PLCs to new ControlLogix units utilizing the Allen-Bradley ControlLogix PLC Conversion Kits. Specifically, new ControlLogix-equipped Master Control Panels (MCPs) were provided and implemented with TESCO providing a conversion of process area I/O to Remote I/O (RIO) controlled by the MCP. TESCO provided modifications to the existing SCRWA control system components and was responsible for the overall systems integration for the project. The existing DataHighway+ network was converted to a new Ethernet network. TESCO also provided new networking gear, SCADA equipment, and low voltage motor control. TESCO field services removed the existing Allen-Bradley PLC-5 systems to new CompactLogix PLCs and provided start-up services for the new blower system and return activated sludge (RAS) pump stations/clarifier.

24 Years of Experience
17 Years at TESCO

SPECIALIZATION

SCADA-HMI, Networking, and Cybersecurity for Water and Wastewater Systems

FIELDS OF SPECIAL COMPETENCE

Design, Specification, Coordination, Management and Implementation of Computer based Systems in the Water and Wastewater Industry

EDUCATION

B.S., Industrial Technology, California State University, Chico:

- Minor: Manufacturing System Management (Robotics, Plastics & CAD/CAM)
- Emphasis: Plastic Manufacturing

CERTIFICATIONS

Siemens TIA Systems Engineering

Siemens TIA Portal Software, Networking, Safety, & SCADA

ICS-Cert: Operational Security (OPSEC) for Control Systems (100W)

ICS-Cert: Cybersecurity for Industrial Control Systems (210W-01)

Schneider Electric: PSXCE Strategic Partner

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Brendon Horn

NETWORK & TELEMETRY MANAGER

As Senior Systems Engineer and manager of TESCO's Networking & Telemetry Department, Brendon Horn brings extensive, practical experience designing and building telemetry systems that connect distributed assets for water operations and processes. He brings a wide range of experience in process control technologies including SCADA, PLCs, Radio, Fiber, and related systems, which provides Brendon with the context and practical skills required to maximize system efficiency and reduce costs for projects of all sizes.

Brendon leads our N&T team in successfully collaborating on a wide variety of projects that range from minor upgrades to existing systems to complex designs for control systems for new water and wastewater treatment facilities and infrastructure.

Brendon has strong analytical, organizational, and problem-solving skills and is known for his ability to accurately identify deficiencies and develop effective design improvement recommendations. Prior to managing TESCO's Networking & Telemetry department, Brendon spent eight years in our Systems Engineering department. A proven team leader with excellent communication skills, he motivates and trains both internal and client staff. Brendon's experience includes projects in the water and wastewater, pharmaceutical, food processing, and aggregate mining industries.

RELEVANT EXPERIENCE

Microwave Radio Replacement, San Jose Water Company (SJWC), CA:
Network Engineer

This project evaluated potential options and feasibility of replacing the outdated, existing telemetry link from the County Communications Center to the Bascom Avenue Campus that included Cambium Networks PTP 800 radios with a firewall and network switch on each end of the link, which is used exclusively for SCADA traffic. Brendon lead the assessment, conducted a radio survey, and developed recommended alternatives with cost estimates for materials, services, and contracted electrical trade labor to implement a reliable solution to replace the existing system. Project challenges included installation of replacement antennas located in elevated terrain, and Brendon coordinated with SJWC and TESCO's Field Service Engineer for simultaneous post-installation antenna alignment for each link during testing and start-up.

Blanco Drain & Reclamation Ditch Diversion Facilities, Monterey Regional Water Pollution Control Agency (MRWPCA, dba Monterey One Water), CA:
Network Engineer

This SRF-funded project demolished the existing facilities and constructed a new drain diversion pump station, intake structure, and approximately 9,400 ;linear feet of diversion pipeline for the Blanco Drain Diversion Facilities, and demolished existing facilities to construct new the Reclamation Ditch Diversion Facilities including pump station, intake structure, discharge piping, and associated electrical, instrumentation, and controls. TESCO provided: engineering services; manufacturing services including fabrication, assembly, equipment wiring, and factory testing; start-up services including installation verification, parameter adjustments, programming, instrumentation configuration, function checks, and project start-up; and provided on-site training and O&M manuals. The project utilizes Allen-Bradley PLCs and VFDs,

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FactoryTalk View Site Edition Visualization SCADA software and FactoryTalk View Historian, Dell PowerEdge SCADA Software Server, Cicso Meraki Wireless Access Points (WAP), VOIP phones, Ethernet switch, Valcom VoIP paging module, VMware virtualization platform, and Ubiquiti airMax Ethernet radios.

SCADA System Upgrade, Mammoth Community Water District, Mammoth Lakes, CA: Network Engineer

This Community Water District was looking to upgrade both communications equipment and technologies as well as programmable logic controllers (PLCs) to increase reliability throughout the system. Performed preliminary RF Analysis using Path Modeling software. Performed Field RF surveys for remote and backbone connections, designed RF networks and selected hardware based on radio survey findings. Configured and tested radio, PLC gateways and networking hardware including protocol gateways to implement the proposed design. Coordinated all FCC licensing applications. Performed and coordinated startup of all RF and network components, verifying functionality with SCADA and process controls.

W1 SCADA Improvements Project, City of Rialto, CA: Network Engineer

This Design-Build project for the City's Water District upgraded the existing SCADA, Allen-Bradley PLC, and communications systems to increase reliability. Brendon performed in a lead role for planning, coordination, and implementation of the cellular communications network. He conducted a field cellular survey to gather data related to communications expectations of the cellular network in the area, and developed reports detailing the survey findings. Also served as the communications lead within the project team for the design and implementation of the cellular communications system for all remote sites, allowing communications between sites for PLC control as well as SCADA monitoring. Coordinated cellular managed private network (MPN) turn-up.

Water Operation SCADA System Project, City of Waterford, CA: Network Engineer

This City took over ownership and operations of the local water distribution and wastewater stations from a previous operator. This Design-Build project replaced existing PLC and radio equipment with Allen-Bradley PLCs and iNET-II radios for eight pump stations and three lift stations, upgraded the City Hall SCADA, and provided field modifications for PLC panels at the water treatment plant and wastewater treatment plant. Brendon performed radio frequency (RF) surveys for remote and backbone connections, designed RF networks and selected hardware based on radio survey findings. He designed an RF network to provide control and operational staff with the ability to monitor all remote sites from multiple locations. Brendon programmed all networking hardware, including routers, switches and radios. He supervised N&T staff in implementation of remote device configurations. He also prepared documentation for all upgraded sites.

TESCO worked collaboratively with the City to discuss, ratify, and memorialize written standards utilizing TESCO's baseline standards as a starting point. Overall, TESCO was responsible for the system's design, networking, manufacture, installation, startup, staff training, and O&M manuals.

Network Reconfiguration, Fontana Water Company, CA: Network Engineer

This project upgraded aging wide area network (WAN), radio, and networking equipment to provide reliable, redundant communication between the Tokay Corporate Yard and the Sandhill Water Treatment Plant. TESCO procured, configured, and commissioned new networking and radio equipment in accordance with the recommendations suggested in the Department of Homeland Security's 2016 SCADA system review. TESCO used the existing Internet service provider (ISP) connections to configure a redundant communication link.

Bridgewave: Installation and Maintenance of Bridge Wave Communications – Gigabit Wireless Products

OSHA: Elevated Work Surface Training

OSHA: Confined Space Training

MSHA Site-Specific Training

Cognex Vision Systems

Adept Technologies System Design and Integration Training

SOFTWARE

HMI: Wonderware InTouch, Wonderware Historian, Intellution iFIX 3.1

RF: Pathloss

Network: Wireshark, Cacti, OpenNMS, Zabbix

Platform: Cisco iOS, MikroTik Router OS Windows

Radio: GE MDS (iNET, SDx, x710), Proxim (Tsunami, GX/QB), Ubiquity (Bullet, Nano, Rocket), Bridgewave

HARDWARE

Network: Cisco (Switches, Routers, Firewalls), Adtran (Routers, DSU), Hirschman (Switches), N-Tron (Switches), Allen-Bradley (Stratix Switches)

Process: Allen-Bradley (Control, Compact, MicroLogix, SLC), Modicon (Unity, Quantum, Momentum)

Protocol: Ethernet, EthernetIP, Serial, ModbusTCP, Modbus, Data Express Plus

PROFESSIONAL ASSOCIATIONS

Homeland Security Information Network

4.5 Years of Experience
4.5 Years at TESCO

SPECIALIZATION

PLC/RTU Programming for Water & Wastewater Energy Systems, with an Emphasis on Schneider Electric Hardware and Software

AUTOMATION PROFICIENCIES

- IEC 61131-3 Languages
- Industrial Protocols
- Modbus/RTU, Modbus+, Modbus/TCP:
  - » Ethernet/IP
  - » Profibus
- Rockwell Suite:
  - » RSlogix 500
  - » Studio 5000
  - » Factory Talk View
- Schneider Electric Suite:
  - » Modsoft, Proworx, Concept, Telepace, Unity, Control Expert
  - » Vijeo Designer
  - » Tesco
- Miscellaneous
  - » ABB
  - » Automation Direct
  - » FastTracks
  - » Maple

CERTIFICATIONS & TRAININGS

- Unity Pro IEC Programming Level 2

Ian Cottengim

PLC APPLICATIONS ENGINEER II

Ian Cottengim specializes in development and application programming of programmable logic controllers (PLCs) and operator interface terminals (OITs) for control systems for municipal and regional water/wastewater treatment facliities and associated infrastructure.

Known effectively collaborating with operations staff to incorporate client feedback into each project, Ian's experience enables him to proactively predict, identify, and address potential issues and challenges during the project design.

Ian approaches each project with a focus on delivering new and upgraded systems that meet the operational goals of the end user. He identifies and communicates operator needs with the project team to foster successful integration of new equipment into existing systems. Ian also brings accurate troubleshooting skills and effective leadership to help expedite the commissioning process.

RELEVANT EXPERIENCE

Penitencia Water Treatment Plant FSA & CTS Process Control Upgrades, Santa Clara Valley Water District (SCVWD), CA: PLC Programmer

To upgrade existing treatment plant processes, TESCO provided new Industrial Control Panels equipped with Modicon PLC and OIT systems, a new telemetry system, and Seismic Switch Control Panels. TESCO also provided and integrated new instrumentation including flow meters and pressure transmitters, and added Modbus Read/Write addressing between the Maple OIT system and the newly-provided Modicon M340. Additionally, TESCO provided factory testing and an in-house demonstration for Valley Water staff.

Ian implemented the new fluorosilicic acid (FSA) and calcium thio sulfate (CTS) treatment process dosing controls. He worked directly with the District's Water Quality Division staff to ensure fail-safe process control for both chemical concentration and pH levels to comply with regulations.

PLC Replacement Project, San Jose Water Company (SJWC), CA: PLC Programmer

For this project, TESCO migrated the existing Schneider Quantum 984 CPUs to Quantum Unity CPUs, at 118 remote sites throughout the District's existing system in the greater San Jose area. Ian collaborated with SJWC staff to implement a baseline program. After implementing a baseline program, Ian visited each remote site to power-down, swap the CPU, test with SCADA, and bring the site on-line.

Regional Ground Water Storage and Recovery, San Francisco Public Utilities Commission (SFPUC), CA: PLC Programmer

This project involved integrating, configuring, and programming new Modicon Quantum and M340 PLCs in Unity. The PLCs were integrated with Operator Interface Terminals (OIT) and networked with multiple communication methods, including Ethernet, CSU/DSU telephone circuits, radio telemetry, and satellite communications. TESCO was responsible for loop and interconnection diagrams, arc flash risk assessment and coordination studies, and communication integration. TESCO provided multiple days of training on the PLC software configuration,

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systems operations, and VFDs, and start-up services for four new well sites and one reservoir. The new well sites include 350-amp turbine motors to produce 1-5 mgd with disinfection. TESCO personnel were on-site to tune the Proportional-Integral-Derivative (PID) controllers for dosing and well pump flow controls.

Ian provided PLC programming to integrate controls of multiple booster pump stations to allow the PLCs to coordinate to reuse recycled treated water from the Goleta Wastewater Treatment Plant. He tuned and optimized a high-visibility booster station to provide stable and energy-efficient discharge pressure regulation. Ian utilized peer-to-peer communications to facilitate the pressurization of regular and high pressure zones serving various elevations.

San José-Santa Clara Regional Wastewater Facility Digester Upgrades, City of San Jose, CA: Lead Technical Coordinator

At the largest advanced wastewater treatment facility in the western United States, TESCO installed multiple ABB motor control centers (MCCs) and distributed control system (DCS) central processing unit (CPU) panels to facilitate a complete overhaul of the aging digesters, with the addition of new systems for dissolved air flotation and foul air recovery.

With ABB sole-sourced as the programmer on this project, Ian coordinated ABB staff, other contractors, and end-user Operations staff to facilitate development and testing of the expanded DCS. TESCO provided a wide range of expertise for this complex upgrade project, including DCS programming, network communications, electrical wiring, construction management, and project management, resulting in a successful project to enhance operational efficiency.

Recycled Water Booster Pump Stations, Goleta Water District, CA: PLC Programmer

Ian coordinated multiple booster stations to reuse recycled treated water from the Goleta waste water treatment plant. He successfully tuned and optimized a high-visibility booster station to provide stable and energy-efficient discharge pressure regulation. Peer-to-peer communications facilitated the pressurization of regular and high pressure zones, which serve both low and high elevations.

Water Quality Control Plant Digester Improvements, City of South San Francisco, CA: PLC Programmer

This project involved the supply and integration of new stainless-steel Remote I/O (RIO) Industrial Control Panels and reconfiguration of existing plant hot standby Schneider PLCs. Responsible for participating in and guiding collaborative workshops, PLC configuration, PLC programming, and system training.

SCADA Master Plan, City of Baton Rouge, LA: PLC Programmer

This successful project deployed the City's first SCADA and cellular communications system across 450 sewage-collection pump stations. All pump stations communicate to a SCADA system that presents key information and alarms in an intuitive view. TESCO provided PLC programming for retrofitting the pump stations with TESCO L2000 PLCs and cellular modems. All pump stations communicate to a TESCO-provided SCADA system.

Ian developed a standard program template with versioning to meet the individual requirements of each site. He participated in a proactive planning process and coordinated with the design team, end user, and internal engineering team to develop hundreds of sites.

- Allen-Bradley/RS-Logix Programming Platforms
- Telepace Studio
- OSHA 10
- Profibus 20 Hour
- Multimeter 20 Hour

5 Years of Experience
4 Years at TESCO

SPECIALIZATION

SCADA Engineering and PLC Programming

FIELDS OF SPECIAL COMPETENCE

Computer Systems / Software Applications Related to Monitoring and Control of Water and Wastewater SCADA Systems

EDUCATION

Bachelor of Science, Computer Engineering (Major), Computer Science (Minor), California State University, Chico

CERTIFICATIONS

Inductive Automation:
Ignition Gold 8
Ignition Perspective

Rockwell Automation:
ThinManager

CYBERSECURITY TRAINING

Cybersecurity for Industrial Control Systems:

- Using the ISA/IEC 62443 Standard to Secure Your Control Systems (IC32E)
- Influence of Common IT Components on ICS (210W-02)

Gabriel Mabalot

SCADA ENGINEERING SUPERVISOR

Gabriel Mabalot is a SCADA Software Applications Engineer with focused experience establishing and providing all of the site-specific software configurations for graphic user interfaces, reporting formats, historical data access, and process monitoring related to SCADA system operational characteristics. He establishes and configures SCADA systems that require a strong customer interface and provide user-friendly, effective data representation to enhance system operations.

Certified by Rockwell and Inductive Automation, Gabriel's extensive experience developing applications and installing new and upgraded control systems for water and wastewater treatment facilities enhances his ability to lead our SCADA engineering team in delivering projects that enhance operational efficiency.

Gabriel develops SCADA system interfaces including graphic user interface (GUI) screens, custom reports, maintenance and energy management, costing, process trending, database requirements, computer access requirements via network or remote systems, data acquisition requirements, manual and automated centralized control programs.

RELEVANT EXPERIENCE

SCADA System Replacement, City of Roseville, CA: SCADA Engineer/ Programmer

TESCO provided design and implementation services for replacement of an existing, aging DYNAC system with GE Intelligent Platform's (GEIP) iFIX and Proficy Historian software. In addition to replacing the DYNAC system for the three Plants, the project implemented iFIX to replace the standalone Wonderware systems at the Dual Purpose Pumping Station, Dry Creek UV systems, and Pleasant Grove UV systems, as well as the Hypochlorite Magelis system at Dry Creek. Beyond the local monitoring and control of their respective facilities, the new SCADA systems also provide remote monitoring and control of water distribution, recycled water, wastewater collection and stormwater facilities via various communications methods.

TESCO provided, installed, and programmed new HMI hardware and software. Data from Proficy Historian was integrated with the existing Oracle HDR system. iFIX now interfaces to a number of different PLC protocols (including Modbus TCP) at plants and remote sites. Gabriel's duties included documenting all points from existing application, database normalization for iFIX addressing, application development, workshop participation, and Factory Acceptance Testing.

Secondary & Tertiary Improvements, City of Davis, CA: SCADA Engineer/ Programmer

This design-build project involved design and integration of a new Hot-Standby Ignition SCADA system. The City accesses the Ignition system via multiple operator workstation computers in addition to portable tablets via Remote Desktop Protocol (RDP) TESCO was responsible for providing redundant SCADA server hardware as well as software, including HMI, Historian, and database software.

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Gabriel manually ported all existing SCADA system configurations and functionality of the predecessor iFIX SCADA system. He provided SCADA system design, specification, development, coordination, implementation, testing, startup and training.

Wells 31, 33, and 34 SCADA Modifications, City of Davis, CA: SCADA Engineer/Programmer

This project involved developing a new SCADA application for multiple City well sites. Application development was based on standards developed for existing well sites. The application was standardized so that it could be dynamically duplicated across all sites. Gabriel was additionally responsible for generating new graphics for the City's newly installed Variable Frequency Drive (VFD) pumps. The SCADA application pulled statistics directly from the VFD for monitoring and trending purposes. Gabriel was also responsible for the on-site testing, commissioning, and training of the system.

Potable Water SCADA & Communication System Replacement, City of Hobbs, NM: SCADA Engineer/Programmer

This project overhauled and modernized the City's potable water process control system. The entire IP-based network infrastructure deployed under this project was implemented in a managed configuration that optimizes operations and provides City staff with advanced system diagnostic capabilities. Improvements implemented by TESCO include standardization, simplicity, modernization, enhanced functionality, increased reliability, integrated diagnostics, critical points of redundancy, and a vast improvement to the City's user experience.

TESCO provided the design, programming, and integration of the new Siemens WinCC OA central SCADA solution for the potable water system. Enhancements included virtualization of the core central SCADA system infrastructure, mobility for operations and technical staff, seamless expansion capabilities for the future, and easily accessible comprehensive system documentation.

Major components included redundant SCADA server host machines, a process historian, multiple connected client nodes, peripheral devices, and a centrally managed network and wireless communication infrastructure to support wide-area network (WAN) connectivity to 43 new remotely located, TESCO-provided Siemens PLCs via radio telemetry. Additional remote site upgrades included the addition of 34 new VFDs provided, configured, and implemented by TESCO. A new wireless RF network operating in the 4.9 GHz licensed frequency band was also designed, tested, and implemented by TESCO. Design for the new communications network infrastructure focused on performance, reliability, security, and longevity.

Potable Water SCADA & Telemetry System Upgrade, City of Lincoln, CA: SCADA Engineer/Programmer

This two-phase project replaces the City's aging potable water SCADA and radio telemetry systems with a comprehensive upgrade to overhaul and modernize the existing process control system, and separate the new water SCADA system from the existing wastewater SCADA system. The system includes remote telemetry units (RTUs) that communicate with three water storage tanks, the Twelve Bridges Booster Pump Station, five well sites, 10 pressure reducing valves (PRVs), and a major pipeline connection incorporated into the new SCADA system.

Major enhancements TESCO recommended and implemented include: virtualization of the core central SCADA system infrastructure; enhanced system visibility and operational mobility for operations and technical staff; seamless expansion capabilities for the future; increased system reliability and enhanced communications; optimized radio system for real-time data; PLC programming continuity; and easily-accessible, comprehensive system documentation.

- Common ICS Components (210W-03)
- Cybersecurity within IT & ICS Domains (210W-04)
- Cybersecurity Risk
- 210W-06 Current Trends (Threats) (210W-05)
- Current Trends (Vulnerabilities) (210W-07)
- Determining the Impacts of a Cybersecurity Incident (210W-08)
- Attack Methodologies in IT & ICS (210W-09)
- Mapping IT Defense-In-Depth Security Solutions to ICS (210W-10)

SOFTWARE / TRAININGS

WinCC: OA Basic Training
Open Architecture Basic Training

Rockwell Automation:

- ThinManager Integrator Training
- ThinManager Experience the Platforms Power and Simplicity: Basic Lab
- PlantPAx System - What's New and What's Next
- Utilizing New FactoryTalk Linx Communications Capabilities with Logix and Access Third Party Components with OPC UA
- Deploy and Manage Virtualized Plant Pax Systems
- FactoryTalk View SE v10.0 Configuration and Maintenance
- ThinManager Delivering and Managing the Connected Enterprise: Overview
- Introducing FactoryTalk Brew: Enterprise-Ready

7 Years of Experience
7 Years at TESCO

SPECIALIZATION

SCADA Engineering

FIELDS OF SPECIAL COMPETENCE

Computer Systems Software Applications Related to Monitoring and Control of Water and Wastewater SCADA Systems

EDUCATION

B.S., Computer Science, California State University, Sacramento

HARDWARE/ SOFTWARE PROFICIENCY

GE Proficy iFIX

GE Proficy Historian

GE Proficy Machine Edition

Rockwell Automation RSLogix 500 & 5000

Windows Server and Terminal Services

Visual Basic, C/C++, Java, Python, and PHP

Hoan Tran

SCADA SYSTEMS ENGINEER II

Hoan Tran is a SCADA Engineer with extensive experience configuring the operational characteristics and user-friendly interfaces that water and wastewater treatment plant operators work with to monitor and manage processes.

Hoan is known for designing intuitive, user-friendly graphical interface screens that enhance real-time process monitoring, historical data access, and practical reporting formats.

In addition to GUIs, Hoan also designs and develops production and usage reports, maintenance reports, energy management and costing reports, process trending, database requirements, computer access requirements via networks or remote systems, data acquisition requirements, as well as manual and automatic centralized control programs. He brings specialized experience software applications related to centralized monitoring and control of SCADA systems for water and wastewater treatment plants and associated facilities.

RELEVANT EXPERIENCE

Sludge Dewatering & Loadout Facility, City of Palo Alto, CA: SCADA Engineer

This $1.3 million project expands and improves the City's existing wastewater and solids handling facilities at the Palo Alto Regional Water Quality Control Plant (RWQCP), with the goal of reducing greenhouse gas emissions (GHGs), eliminating a hazardous waste stream, and reducing energy costs.

TESCO managed the design and implementation of new switchgear, motor control centers (MCCs), instrumentation, and system integration within the new facility, which successfully met the City's combined goals of mitigating the RWQCP's escalating maintenance costs and reducing greenhouse gas emissions (GHGs). To achieve this goal, TESCO provided engineering services including seismic calculations, loop and interconnection wiring diagrams, short-circuit study, protective device coordination study, and a loop specification review workshop for City staff. TESCO was also responsible for fabricating, manufacturing, and assembling a new Allen-Bradley equipped PLC control panel; providing PLC programming services for the Allen-Bradley ControlLogix, and SCADA programming for the General Electric iFIX application.

Hoan created a new set of iFIX 5.8 SCADA screens and tag database to meet the existing SCADA standards for the facility. He integrated the new station into the main SCADA application to provide operators with easy access from any server and the ability to view nodes at the plant. Hoan also configured the Proficy Historian server and scripted a custom alarm/event screen to allow the operators to track all historical events and alarms for troubleshooting purposes. He provided training to the operators to enable them to use the new SCADA system to control the dewatering process.

SCADA & RF Services, City of Manteca, CA: SCADA Engineer

This project involved PLC programming at several existing stormwater sites in order to integrate the sites into the City's existing iFIX SCADA application. Front-End-Processor (FEP) programming was necessary to tie communication with the new sites into iFIX. Hoan designed the iFIX SCADA screen for seven storm drainage/wastewater lift stations and integrated them into the City's existing SCADA application. He reconfigured the existing Modbus Ethernet Driver to poll the new sites via FEP PLC.

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Hoan also modified the WIN-911 configuration to add new critical alarm call-outs. He designed a new plant overview screen to be displayed on the big screen TV to provide operators with a quick, at-a-glance view of all important analog readings (including levels, flows, and turbidity) as well as the discrete alarms. Hoan also provided optimized Excel spreadsheets to enable quicker report generation on daily flow totals, and he e created the automated process to allow the daily flow totals to be imported into the existing Dream Report templates.

Water Reclamation Facility (WRF) SCADA System Upgrades, San Elijo Joint Powers Authority, Cardiff-by-the-Sea, CA: SCADA Engineer

TESCO provided engineering design, SCADA, PLC, and OIT programming, network & telemetry, field services, start-up, training, and O&M manuals for a project to upgrade an existing SCADA system at the San Elijo Water Reclamation Facility. TESCO upgraded the existing Wonderware InTouch SCADA software to Wonderware System Platform with Wonderware Historian. TESCO installed VMware ESXi 6 on new host SCADA servers and provided configuration and testing in a virtualized environment. TESCO also upgraded the existing WIN-911 alarm notification software to the most recent version and configured it for automatic fail-over.

Existing operations workstations received new Thin Client terminals and operations staff also received three portable, cellular table terminals to provide remote full virtual access. The new SCADA system was also integrated at five remote pump station facilities. TESCO also developed a Cybersecurity Plan with recommended improvements for the Authority to harden the new SCADA system against intrusion. Hoan was responsible for setting up and configuring the ESXi 6.7 virtualization environment, the Windows Server 2016 domain controller, remote desktop services, McAfee Epolicy Orchestrator, Veeam Backup, the 2017 Wonderware System Platform, and the TopView alarm management and notification auto dialer.

McKinley Village Storm Drain Pump Station & Sanitary Lift Station, City of Sacramento, CA: SCADA Engineer

TESCO supplied new MCCs, a PLC control panel, and various instrumentation for the McKinley Village Storm Drain Pump Station and Sanitary Lift Station project, which upgraded existing facilities to mitigate stormwater runoff that could violate the City's National Pollutant Discharge Elimination System (NPDES) permit and cause combined sewer system overflows.

Hoan was responsible for integrating the pump station and lift station into the City's existing Trihedral VTScada software platform used for their main SCADA system. He developed new SCADA screens/graphics and tag naming databases to incorporate the new sites. Hoan also configured new alarms and created an alarm index screen.

Water Pollution Control Facility (WPCF) Aeration System Retrofit, City of Woodland, CA: SCADA Engineer

Hoan was responsible for SCADA System development, expansions, modifications, enhancements, user support, user group policy deployment, and system maintenance. The system included redundant iFIX SCADA servers using enhanced fail-over, a Proficy HISTORIAN server, and an iFIX iClient Terminal Server for remote access. Hoan provided seamless conversion from GE PLCs to new Allen-Bradley PLCs, and integrated controls for critical in-plant processes at the wastewater treatment plant. Hoan also developed a new set of iFIX screens and tag databases to provide monitoring and control of the new aeration basins and blower buildings.

SCADA Replacement, Upgrade to iFIX 5.8 from iFIX 3.5, California American Water, Sacramento: SCADA Engineer

In addition to upgrades and modifications for various water distribution facilities for California American Water's Sacramento system, Hoan installed and configured a new fully-redundant iFIX SCADA system, I/O Driver, Historian, and Terminal Servers. Additionally, he performed full SCADA application conversion from iFIX 3.5 to iFIX 5.8, including converting classic Historian to the new Historian 5.5. He developed upgraded HMI graphical screens, reconfigured drivers and implemented upgrades to support the application upgrades. Hoan converted the existing SCADAlarm call-out system to a new, redundant WIN-911 configuration.

12 Years of Experience
2 Years at TESCO

SPECIALIZATION

PLC/RTU Programming for Water/Wastewater Systems

FIELDS OF SPECIAL COMPETENCE

Programming of PLC/RTU, OIT, & Instrumentation Applications Related to Monitoring and Control of Water and Wastewater SCADA Systems

EDUCATION

A.A.S., Electrical & Instrumentation Technology, Yavapai County Community College, Arizona

Vocational Degree, Electronics Technology, Warren County Technical School, New Jersey

CERTIFICATIONS

Allen-Bradley/RS-Logix Programming Platforms

Modicon IEC Level 1 & 2

Concept Programming

Unity Programming

Unity Pro IEC Programming Level 2

William Peters

PLC PROGRAMMER

William Peters is a PLC Applications Engineer specializing in providing design, programming, and implementation of programmable logic controllers (PLCs), process controllers, Operator Interface Terminals (OITs), remote telemetry units (RTUs), and associated instrumentation related to industrial and municipal water and wastewater applications.

William is known for accurately evaluating control system requirements and developing specifications for the control programs required to implement the control scheme.

William establishes and specifies control system requirements, develops control programs for RTUs and PLCs, develops OIT and HMI screens, sets up communication interfaces, and configures programmable instruments and single-loop controllers. He also provides training for client operations staff on PLC functionality.

RELEVANT EXPERIENCE

Headworks Critical Improvements Project, City of San Jose, CA:
PLC Programmer

TESCO provided on-site reconfiguration of existing Bar Screen Control Panels, including retrofitting new Variable Frequency Drives (VFD), purge systems, and pressure monitoring kits. William was responsible for providing all necessary applications programming of three Programmable Logic Controllers (PLC), Operator Interface Terminals (OIT), and VFDs. Additionally, William conducted on-site field testing, product start-up, and commissioning. He additionally provided overview training of the new PLC programs.

Avalon Lift Station Motor Control Center, Westborough Water District, South San Francisco, CA: PLC Programmer

This project modifies the existing Allen-Bradley CompactLogix PLC at the Avalon Lift Station in order to deliver digital output signals to the existing on-site HSQ RTU that communicates with the District's SCADA system, with the ability to indicate whether the pumps are running in variable frequency drive (VFD) or Bypass mode. William provided PLC programming, testing, integration, and start-up services. Automatic level controls and pump alternation were incorporated into the site.

Skyline Lift Station Pump Control Panel, City of Daly City, CA: PLC Programmer

This project modernizes an existing wastewater lift station that includes four 25 hp pumps, a wet well, and submersible level transducer. The pumps are grouped in two operating pump sets to allow for lead-lag control and pump set alternation. TESCO supplied and integrated a new pump control panel adjacent to the existing on-site RTU panel, to reduce the need for running new conduit in terminating the pump leads and interface with I/O wires fed from the HSQ PLC. TESCO furnished the new pump control panel with four 30 HP VFDs to modulate the speed of the pump motors and an Allen-Bradley CompactLogix PLC to automate lift station operations. The panel also included bypass contactors to allow pumps to run in the event of VFD failure. TESCO also mounted an A/C unit and 5 KVA transformer to step down the incoming 480 VAC utility power to 120 VAC to supply power to the PLC and pump controls.

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San Mateo, Dumbarton, and Bay Bridge Fog Horn and Lighting Project, California Department of Transportation (Caltrans), San Mateo, CA: **PLC Programmer**

This project upgrades the system used by the California Highway Patrol to issue fog advisories for the San Francisco-Oakland Bay Bridge, San Mateo Bridge and Dumbarton Bridge to alert the public about safety and visibility concerns. TESCO provided programming modifications and integrated the updates to the iFix SCADA and ten GE RX3i PLCs. William updated PLC control logic to monitor the bridge lighting systems for failures and transmit the information back to SCADA, where new graphics were created for the alarm system. A fog monitoring and annunciation system was connected on the Dumbarton and Bay Bridges using Modbus RTU communications. William updated the produced-consumed tables for each bridge and added programming to pass the fog system data to SCADA and allow Caltrans personnel to test the system remotely. TESCO also provided field services during installation and start-up, as well as on-site training and detailed O&M manuals.

PLC Upgrade at Lante Water Treatment Plant, Valley County Water District, Baldwin Park, CA: **PLC Programmer**

This project involved replacing all existing Modicon 984 PLCs at the Lante Water Treatment Plant. TESCO fabricated and pre-assembled seven new Modicon M340 PLC back pans to be retrofitted into the existing plant enclosures. William converted the entire plant PLC system from Modicon Momentum to the newer M340 series. He also conducted field testing, product start-up, and staff training on the new PLC systems.

SCADA & RF Services, City of Manteca, CA: **PLC Programmer**

TESCO provided PLC programming at several existing stormwater sites in order to integrate the sites into the City's existing iFIX SCADA application. TESCO provided Front-End-Processor (FEP) programming necessary for communication with the new sites be tied into iFIX. William provided all necessary PLC programming, including adding HART data routines to a CompactLogix PLC and facilitated communications of HART variables over a cellular network. He also provided on-site testing, product start-up, and staff training on the new PLCs.

Bellcrest Lift Station Upgrades – Programming & OIT Modifications Plus New Alarm and RTU Alarm, City of Daly City, CA: **PLC Programmer**

This project modernizes the existing Bellcrest Lift Station pump control system by adding a programmable logic/pump controller and new alarming capabilities to reduce the antiquated cam-switch system and relay controls, and provide the City with a pumping system that allows more flexibility for future needs. Although the City recently implemented upgrades to the Bellcrest Lift Station, which includes a pump control panel with four 25hp pumps with 30hp drives for the motor controls/soft state starters, the existing equipment continued to experience electrical issues and failures. TESCO engineered and designed the new Pump Control Panel to retrofit into the existing space, replacing the existing Pump Control Panel in entirety and allow for ease of installation.

TESCO manufactured and provided a new pump control panel that includes monitoring and control signals, new Reduced Voltage Solid State (RVSS) Soft-Starter Drives to contain integral bypass for 100% voltage/Hz/speed pass-through of electrical current, which provides reduced heat generation, thereby expanding longevity of each drive. The new Pump Control Panel has the required monitoring and control signals that are terminated to terminals for hardwire I/O interface for/to the existing HSQ RTU system. William programmed the new Allen-Bradley CompactLogix PLC to automatically switch both pumps to run through bypass contractors, so the new OIT display shows when pumps are switched to bypass automatically. TESCO also provided documentation including as-built record drawings and O&M manuals.

PROFICIENCIES

PLC Systems, Current and Legacy

- Allen-Bradley
- GE
- Schneider

OIT Systems

- PanelView OIT
- QuickPanel OIT
- Automation Direct OIT

SCADA Systems

- iFIX
- Wonderware (now AVEVA)
- Delta V

4 Years of Experience
<1 Year at TESCO

EDUCATION

B.S. & M.S., Electrical and Computer Engineering, University of Patras, Greece

PLC/OIT SOFTWARE

- Schneider ControlExpert (Formerly Unity Pro)
- Schneider EcoStruxure Operator Terminal Expert (Formerly Vijeo Designer)

MODELING AND ANALYSIS

- AutoCAD
- Revit
- Labview
- Simscape (Simulink)

OTHER SOFTWARE

- Python
- Matlab
- C, C++
- Assembly (TS320, 8085)

ASSOCIATIONS

Electrical Engineering Students' European Association (EESTEC), 2018 Academic Team Member

LANGUAGES

- Greek: Native
- English: Fluent
- French: Intermediate, DELF A2 Certificate

Sofia Panagopoulou

PLC APPLICATIONS ENGINEER I

Sofia Panagopoulou is a junior applications design engineer with experience developing electrical design drawings including control wiring diagrams, panel elevation design, bill of materials, power calculations for wastewater treatment facilities and associated sewer collection system infrastructure.

Sophia's strong modeling and analysis skills enhance her ability to develop designs for upgraded control systems water/ wastewater treatment plants, water supply, and sewer collection systems that must remain operational during construction.

After earning her Bachelors of Science and Masters degrees in Electrical and Computer Engineering with a focus on robotics, industrial automation, control systems, digital signal processing, biomechanics, 3D modeling and computational geometry, pattern recognition and adaptive, intelligent, non-linear and digital controls, Sophia served as a design intern for the City of San Francisco Department of Public Works. During her studies, Sophia completed three separate design internships for electrical and mechanical consulting engineers and construction firms in Greece.

RELEVANT EXPERIENCE

Treasure Island Sub-Phase 1B, 1C, 1E & Design/Build Storm Stations, City and County of San Francisco, San Francisco, CA: Programmer

This project constructs a new City neighborhood on Treasure Island in a 300-acre area that includes neighborhood and shoreline parks, sports fields, wetlands, urban farm, and large areas for passive recreation and native habitat. The site of the former Naval Station Treasure Island (NSTI), Treasure Island and Yerba Buena Island are owned by the U.S. Navy. NSTI was closed in 1997, but the remaining facilities include a U.S. Coast Guard Station and Sector Facility, a U.S. Department of Labor Job Corps campus, and Federal Highway Administration land occupied by the San Francisco-Oakland Bay Bridge and tunnel structures.

TESCO participated in the construction and implementation of several new storm stations. TESCO fabricated, manufactured, and supplied new custom stainless steel switchboards, service pedestals, and motor control centers (MCCs) equipped with Modicon M340 Programmable Logic Controller (PLC) systems and Modicon Magelis 15-inch Operator Interface Terminals (OITs). TESCO provided comprehensive PLC and OIT configuration, programming, and testing services on all control components project-wide.

Sanitary Sewer Pump Stations Replacement – Priority 2, San Francisco International Airport (SFO), CA: Programming Standards Development

As a subcontractor to the Austin Webcor Joint Venture for a project to replace and upgrade 15 existing sewer pump stations at the SFO wastewater treatment plant, TESCO was selected to provide systems integration services including SCADA , PLC, and OIT programming, engineering design, radio licensing and configuration, and system installation, factory testing, integration, and start-up. TESCO designed and is implementing programming modifications to the existing Wonderware (now AVEVA) System Platform, as well as programming for the new SCADAPack, Automation Direct, C-More, and Schneider Electric Remote Connect PLCs. TESCO is responsible for providing radio licensing and configuration services before updating the links to

TESCO CONTROLS, INC.

the upgraded SCADA system. TESCO's scope of work also includes manufacturing, assembling, and wiring the new MCCs with associated power supply and HMIs, and provide all instrumentation.

To meet the project schedule, TESCO procured the long-lead time items in advance, including System Platform SCADA-HMI, Thin Client hardware and Prosoft Protocol Converters, PLC enclosures, MOXA Protocol Converter for interface to SBR, as well as miscellaneous parts to construct the PLC panels.

Sofia is currently developing standardized templates for Lift Station and Storm Station PLC Programs for the system updates migrating from existing Control Microsystem SCADAPack and HSQ controllers to Schneider Electric SCADAPack controllers.

RELEVANT EXPERIENCE & REFERENCES

INDUSTRY RECOGNITION DEMONSTRATES TESCO'S DEDICATION TO SUPPORTING CRITICAL WATER/WASTEWATER SYSTEMS

As one of the largest systems integrators in North America focused on this market, TESCO is uniquely qualified to design and build advanced control systems for the industry. Over 95% of our projects are water/wastewater systems or renewable energy projects in the water/wastewater sector. Our year-over-year success is demonstrated not only by the long-term employee-owner staff and company growth, but in being recognized within the industry:

- **Ranked #10 for all control system disciplines** internationally in the *2020 System Integrators Giants List* by Control Engineering.
- Listed as one of the **top 10 companies leading the global water/wastewater management and operational control market** according to *Transparency Market Research* in December 2017.
- Named **"System Integrator Market for Industrial Automation by Service Outlook...Global Outlook to 2022"**, published by *MarketsandMarkets* in April 2017, with TESCO listed as a key player.

THE RIGHT EXPERIENCE TO ACHIEVE VALLEY WATER'S OBJECTIVES

TESCO's primary focus is on projects involving automated control systems for water/wastewater treatment plants and associated infrastructure, and our experience proves that our best solutions incorporate input from the operators. The familiarity of the maintenance and operations staff have with existing systems, and their "wish lists" of improvements to optimize operational efficiency provide TESCO with direction to apply our expertise in the planning, design, implementation, and integration of automated controls systems and SCADA upgrades.

Because mitigating system downtime is a high priority, we utilize a highly-collaborative approach that solicits input from Valley Water staff and project stakeholders to confirm proper planning.

Our recent and ongoing experience with municipalities of similar size and scale (including the cities of San Mateo and Roseville, California, and the City of Baton Rouge, Louisiana) demonstrate our ability to deliver a project that incorporates your goals for resiliency, cybersecurity, operational efficiency, regulatory compliance, and provides Valley Water with effective systems integration services. We understand from experience the need to deliver projects that provide consistent operator experience, leverage technology for the greatest return on investment, and minimize operational impact during modernization of brownfield installments.

The following table lists three recent, relevant projects that are summarized in the following pages, with contract amounts, relevant project components, and client reference contact information.

PROJECT NAME / OWNER AGENCY	TESCO'S ROLE	DATES
Sewage Collection SCADA System City of Baton Rouge, LA	Prime Contractor	June 2013 – December 2019
SCADA System Replacement City of Roseville, CA	Prime Contractor	August 2013 – September 2018
WWTP Immediate Action Phase 1 City of San Mateo, CA	Systems Integration Subcontractor	February 2016 – August 2019

Client Commendation – City of Baton Rouge

"TESCO has provided this Parish consistently reliable pump station control equipment and support services for more than 20 years. Their commitment to supporting supplied products and services is unsurpassed and demonstrated by their approach to fulfilling all tenets of the Baton Rouge SCADA construction project.

Of the nearly 500 pump stations operated by the Department, 375 are reliably communicating in "real time". The system has been successfully utilized to control flow rates to the major treatment plants during major rain events and/or diminished sewerage system capacity. Maintenance personnel are alerted before issues with pump station operations become critical. The ability to monitor all aspects of pump station operation and the generation of emergency alarms has greatly reduced sewage overflows and damage to property.

The robust architecture of this proficiently constructed and commissioned SCADA system is a testament to the thoroughly professional commitment TESCO Controls, Incorporated approaches each endeavor. We look forward to a continued favorable business partnership with such a consistently reliable organization."

Details of TESCO's successful Baton Rouge Sewage Collection SCADA System project are included on the next page.

—Mr. John P. Ward, SCADA System Manager, Department of Environmental Services, City of Baton Rouge / Parish of East Baton Rouge, LA

SEWAGE COLLECTION SCADA SYSTEM

City of Baton Rouge, Louisiana

TESCO served as prime contractor for the development and implementation of the first City-wide sewage collection SCADA system with GE iFIX. The solution included extensive electrical and control modifications at 450 pump stations, construction of two control rooms, and a private cellular network.

Due to a history of accidentally discharging untreated wastewater into rivers, streams and neighborhoods, the City/Parish signed a 2002 Federal consent decree committing to a $1.6 billion program to add capacity and rehabilitate sewer lines. The program included an enterprise SCADA system to monitor operations throughout their 85-square mile service area.

In 2013, following a multi-decade relationship, the City/Parish selected TESCO as their prime contractor to deliver the SCADA solution – a mainstay of the SSO program and a catalyst for overall success. Today, City operators have system-wide insight into real-time operations and receive alerts of pending trouble. If a pump stops unexpectedly or a wet well reaches a pre-set level, maintenance teams have time to correct problems before a spill occurs. **TESCO delivered a new system that provides intuitive, actionable views that let them detect problems remotely and respond in a timely manner – a key strategy required to eliminate Sanitary Sewer Overflow (SSO) events.** Highlights of this project include:

Extensive Modifications: Existing pump sites were built over several decades using different equipment and designs. The upgrade required a thorough site-by-site investigation, detailed design, extensive electrical modifications and PLC replacements. The resulting solution established a common control system and interface across all pump stations.

Services and Equipment: As prime contractor, TESCO developed detailed design then procured, programmed, configured, tested, delivered, and commissioned all equipment and software. TESCO supervised electrical and general contractors throughout field and control room installation. TESCO integrated 20,000 physical I/O points in a GE iFIX SCADA system and historian to monitor 450 pump stations from two new control rooms and data centers.

Intuitive Interface: TESCO developed a GIS-style interface that helps operators quickly identify sites with any of 10 critical alarms – all on one master screen. Predefined alarms warn operators about high wet well levels, power failure, generators with low fuel, etc. Operators can then drill down to reveal additional site-specific details.

Resilient Operations: TESCO designed a virtualized, fully-redundant, fault-tolerant system providing automatic recovery from any system failure. In addition, a separate disaster-recovery control room supports operational continuity in case the primary control center is lost in a catastrophe.

OWNER AGENCY:
CITY OF BATON ROUGE

REFERENCE
John P. Ward
Collections Manager
225.367.4179
jpward@brgov.com

CONTRACT
$14,591,553*
*$16,107,031 for initial contract in program, $40M program total

DATES
June 2013 – December 2019

TEAM
- PLC Programmer: **Ian Cottengim**
- Networking & Telemetry: **Brendon Horn**

RELEVANCE TO VALLEY WATER
- Upgraded aging system to GE iFIX
- PLC upgrades
- Constructed during continuous system operation
- Procurement
- Installation
- Programming
- Testing
- Integration
- Start-Up
- Staff Training
- O&M Manuals

TESCO CONTROLS, INC.

Client Commendation – City of Roseville

"In 2013, the City of Roseville Environmental Utilities Department (EUD) completed a formal Design-Assist RFP process and selected WT-Roseville joint venture to complete a project to replace our three legacy DYNAC VMS-based SCADA systems with GE iFIX SCADA systems. The joint venture was comprised of TESCO Controls Inc. (TESCO), and an engineering firm.

The project started with TESCO functioning as the technical lead for the joint venture, while partnering with EUD and CH2M, EUD's engineering consultant, to transform the preliminary design into a final design. The updated design included extensive "what-if" analysis of all facets of the original design. As a result of these analysis, nearly every element of the original design was enhanced; including adding redundancy elements to the hardware and software, and significantly revising the network architecture. The network enhancements also ensured our new SCADA system was compliant with NIST and AWWA cybersecurity guidelines.

EUD introduced an additional layer of collaboration for TESCO, when we engaged the Department of Homeland Security (DHS) ICS-CERT staff to perform a facilitated cybersecurity evaluation (CSET) on the draft final design, then a Design Architecture Review (DAR) on the final design, and finally the Network Architecture Verification and Validation (NAVV) testing on the operating system. Following the NAVV, DHS provided outstanding feedback regarding the efforts of the technical team led by TESCO staff; including the following quoted observed strengths:

- *"Good segmentation and control of data flow"*
- *"Highly skilled and Knowledgeable IT and OT staff"*
- *"Significant collaboration in designing and implementing the new SCADA system"*

TESCO also led the effort to convert the DYNAC databases to a format suitable for importing into iFIX. The two databases are fundamentally much different from each other, thus in many cases, a single point in the DYNAC database resulted in several points in the iFIX database. Their proper alignment of the various tags versus their virtual states was challenging and required the generation of thousands of new SCADA tags that conformed to EUD standards. Their efforts allowed EUD staff to standardize all of the existing tags and the associated descriptions in the database.

Before the second SCADA system FAT was completed, TESCO's joint venture partner was dissolved, forcing TESCO to complete the project on their own. TESCO has not shrunk from this new challenge, and is working diligently to complete the project on schedule and within the defined budget. There are many more elements to the project where TESCO has brought their excellent technical knowledge, skills and abilities to bear; so this only covers some of the big challenges."

—Mr. Charles K. Aycock, EIM Systems Coordinator, City of Roseville Environmental Utilities Department

SCADA SYSTEM REPLACEMENT

City of Roseville, California

TESCO worked with the City of Roseville Environmental Utilities Department (City) to migrate three, proprietary, aging distributed control system (DCS) systems and other HMIs to GE's iFIX SCADA. The new system retained the City's proven control schemes, functionality and operational history while adding a state-of-the-art, user-friendly interface that enables comprehensive water and wastewater operations management, analysis and control.

Aging System Needing Replacement: The City operates a 100 mgd water treatment plant, two wastewater treatment plants (12 mgd and 18 mgd), and a dual-purpose pump station to serve 132,671 residents across their 50-square mile service area. After 25 years of use, the Transdyn DYNAC DCS and other control systems were unsupported and at the end of their useful life.

Implementation of New SCADA System: Following a SCADA master plan and 60 percent design (by CH2M Hill, now dba Jacobs), the City selected GE iFIX and Historian. The City selected TESCO to deliver a turnkey solution through a collaborative, "Design-Assist" approach. TESCO provided design and implementation services for the replacement of the existing DYNAC system with GE iFIX and Proficy Historian software. In addition to replacing the DYNAC system for the City's three treatment plants, the City also implemented iFIX to replace the standalone Wonderware systems at the Dual-Purpose Pumping Station, Dry Creek UV systems, and Pleasant Grove UV systems, as well as the Hypochlorite Magelis system at the Dry Creek facility.

Benefits of the New System: The new SCADA systems provides remote monitoring and control of treatment processes, water distribution, recycled water, wastewater collection, and stormwater facilities via various communications methods. New HMI hardware and software was provided, installed, and programmed by TESCO. Data from Proficy Historian was integrated with the existing Oracle HDR system, plus iFIX interfaces with a number of different PLC protocols (including Modbus/TCP) at plants and remote sites. TESCO developed a tool for transitioning the existing DYNAC (DCS) databases for all three plants to the new iFIX systems.

Cybersecurity Architecture: TESCO also hosted a Department of Homeland Security (DHS) audit to review physical security, cybersecurity (CSET facilitated), design architecture (DAR) and conduct Network Architecture Verification and Validation (NAVV). The system architecture allows business users unprecedented access to operational history without compromising security.

The resulting system added redundancy, applied security practices for defense in depth, and streamlined reporting.

OWNER AGENCY:
CITY OF ROSEVILLE

REFERENCE
Ken Glotzbach
Project Manager/
EIM Systems Coordinator
(Retired from City October 2019)
916.768.6559 mobile
charles@
muniauto.onmicosoft.com

CONTRACT
$7,719,000

DATES
August 2013 –
September 2018

RELEVANCE TO VALLEY WATER

- Modicon PLC Integration into iFIX SCADA
- Procurement & Installation
- Programming
- Testing & Integration
- Start-Up, Staff Training, and O&M Manuals

TESCO CONTROLS, INC.

WWTP IMMEDIATE ACTION PHASE 1

City of San Mateo, California

For this $5.59 million project, TESCO provided new Industrial Control Panels (ICPs) equipped with Allen-Bradley ControlLogix PLCs, Remote I/O (RIO) Panels, Communication Cabinets, VFD Panels, and Motor Control Centers (MCCs). A PlantPAx-compliant bottom-end with all Allen-Bradley PLC systems was implemented while maintaining a Wonderware top-end.

Custom Solutions: The primary project challenge was devising a method by which two complex and disconnected systems, PlantPAx and Wonderware, can work in concert. TESCO provided all necessary Allen-Bradley PLC programming by utilizing the Rockwell Automation Process Object Library (POL) and using PlantPAx methodologies. TESCO constructed a graphics object library within the Wonderware System Platform to link the PlantPAx POL blocks from the PLCs.

Documentation and Staff Training: TESCO investigated the existing infrastructure and documenting all existing controls, wire sizes, and conduit sizes. TESCO also conducted multiple collaborative PLC Programming Workshops and System Configuration Meetings. TESCO also performed factory testing, field demonstration testing, and system training.

TESCO is currently working on Phase 2 of the WWTP Immediate Action Project, in addition to providing the City with ongoing EMASS Support Services.

OWNER AGENCY: CITY OF SAN MATEO

REFERENCE
Dan Orfescu
WWTP Supervisor
650.437.4180
dorfescu
@cityofsanmateo.org

CONTRACT
$5,597,650

DATES
February 2016 – December 2018

TEAM
- Field Services: **Wess Wissinger, CCST**
- Networking & Telemetry: **Brendon Horn**

RELEVANCE TO VALLEY WATER
- Upgrades to existing PLCs, control panels, and SCADA system at an operating Treatment Plant
- Procurement
- Installation
- Programming
- Testing
- Integration
- Start-Up
- Staff Training
- O&M Manuals

We're Here for You

24 / 7 / 365

TESCO CONTROLS, INC.

8440 Florin Road | Sacramento, CA 95828
916.395.8800 | sales@tescocontrols.com | TescoControls.com

Rajasegaran.Ponniah

From: Tim Fassio <tfassio@tescocontrols.com>
Sent: Tuesday, March 30, 2021 9:15 AM
To: Bradley.Tusup
Cc: Rajasegaran.Ponniah
Subject: [EXTERNAL] RE: Spec Section Qualifications

Confirmed.

The flow meter cut sheet was sent this morning and needs to be included in your bid as well. (flow meter is sole sourced)

Tim Fassio
Sales Estimator

Office 916.395.8800 ***Ext.*** 24674
Direct 916.596.4674 ***Cell*** 916.698.9142
Fax 916.429.2817
Tesco Controls, Inc.
8440 Florin Road, Sacramento, CA, 95828
www.TescoControls.com | map | email

From: Bradley.Tusup <Bradley.Tusup@kiewit.com>
Sent: Tuesday, March 30, 2021 9:08 AM
To: Tim Fassio <tfassio@tescocontrols.com>
Cc: Rajasegaran.Ponniah <Rajasegaran.Ponniah@kiewit.com>
Subject: Spec Section Qualifications

Tim,

Per spec section 13400 1.05.I, please confirm that Tesco has "showed intent to use equipment as specified herein and in other Sections of the Contract Bids".

Alongside this, please confirm Tesco will provide the flow meter per spec section 15200 2.04.

Thanks,

Kiewit

Bradley Tusup
Electrical Estimator

KIEWIT INFRASTRUCTURE WEST CO
4650 Business Center Dr.
Fairfield, CA 94534
(707)-301-3406

TI01046D/06/EN/09.20
71453947
2020-01-01

Technical Information
Proline Promag W 400

Electromagnetic flowmeter

Versatile standard flowmeter for the water and wastewater industry

Application

- The bidirectional measuring principle is virtually independent of pressure, density, temperature and viscosity
- Ideal for water measurement, e.g. drinking water, utility water and industrial/municipal wastewater

Device properties
- International drinking water approvals
- Degree of protection IP68 (Type 6P enclosure)
- Approved for custody transfer to MI-001/OIML R49
- Transmitter housing made of durable polycarbonate or aluminum
- WLAN access
- Integrated data logger: measured values monitoring

Ihre Vorteile

- Reliable measurement at constant accuracy with 0 x DN inlet run and no pressure loss
- Flexible engineering – sensor with fixed or lap-joint process connections
- Application fitness – EN ISO 12944 corrosion protection for underground or underwater installation
- Improved plant availability – sensor compliant with industry-specific requirements
- Safe operation – no need to open the device due to display with touch control, background lighting
- Time-saving local operation without additional software and hardware – integrated web server
- Integrated verification – Heartbeat Technology

Table of contents

About this document

Symbols

Electrical symbols

Symbol	Meaning
	Direct current
	Alternating current
	Direct current and alternating current
	**Ground connection** A grounded terminal which, as far as the operator is concerned, is grounded via a grounding system.
	**Protective Earth (PE)** A terminal which must be connected to ground prior to establishing any other connections. The ground terminals are situated inside and outside the device: ▪ Inner ground terminal: Connects the protectiv earth to the mains supply. ▪ Outer ground terminal: Connects the device to the plant grounding system.

Communication symbols

Symbol	Meaning
	**Wireless Local Area Network (WLAN)** Communication via a wireless, local network.
	**Bluetooth** Wireless data transmission between devices over a short distance.
	**LED** Light emitting diode is off.
	**LED** Light emitting diode is on.
	**LED** Light emitting diode is flashing.

Symbols for certain types of information

Symbol	Meaning
	**Permitted** Procedures, processes or actions that are permitted.
	**Preferred** Procedures, processes or actions that are preferred.
	**Forbidden** Procedures, processes or actions that are forbidden.
	**Tip** Indicates additional information.
	Reference to documentation.
	Reference to page.
	Reference to graphic.
	Visual inspection.

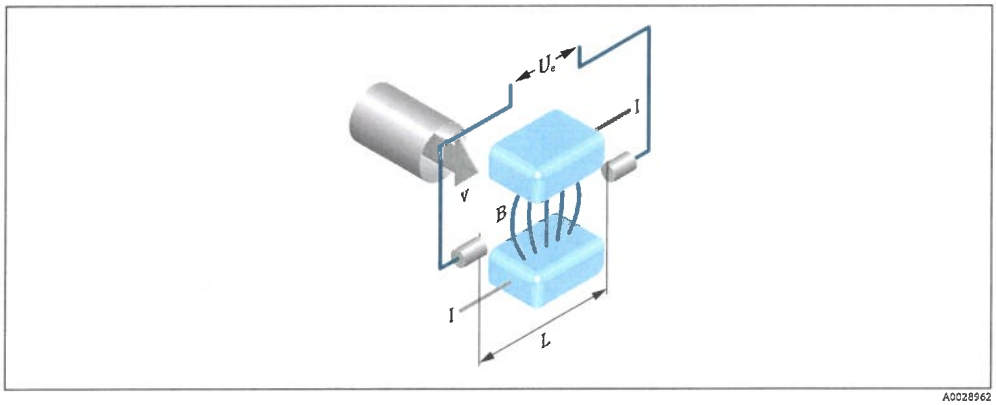
Symbols in graphics

Symbol	Meaning
1, 2, 3, ...	Item numbers
1., 2., 3., ...	Series of steps
A, B, C, ...	Views
A-A, B-B, C-C, ...	Sections
	Hazardous area
	Safe area (non-hazardous area)
	Flow direction

Function and system design

Measuring principle

Following *Faraday's law of magnetic induction*, a voltage is induced in a conductor moving through a magnetic field.



A0028962

Ue *Induced voltage*
B *Magnetic induction (magnetic field)*
L *Electrode spacing*
I *Current*
v *Flow velocity*

In the electromagnetic measuring principle, the flowing medium is the moving conductor. The voltage induced (U_e) is proportional to the flow velocity (v) and is supplied to the amplifier by means of two measuring electrodes. The flow volume (Q) is calculated via the pipe cross-section (A). The DC magnetic field is created through a switched direct current of alternating polarity.

Formulae for calculation

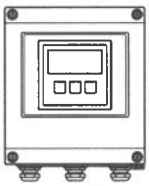
- Induced voltage $U_e = B \cdot L \cdot v$
- Volume flow $Q = A \cdot v$

Measuring system

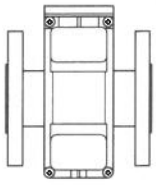
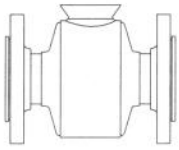
The device consists of a transmitter and a sensor.

Two device versions are available:
- Compact version – transmitter and sensor form a mechanical unit.
- Remote version - transmitter and sensor are mounted in separate locations.

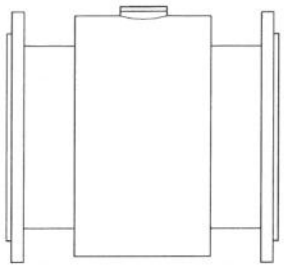
Transmitter

Proline 400
 
A0017117
	Device versions and materials
	▪ Compact version: compact housing
	  ▪ Polycarbonate plastic
	  ▪ Aluminum, AlSi10Mg, coated
	▪ Remote version: wall-mount housing
	  ▪ Polycarbonate plastic
	  ▪ Aluminum, AlSi10Mg, coated
	Configuration:
	▪ External operation via four-line, illuminated local display with touch control and guided menus ("Make-it-run" wizards) for applications
	▪ Via operating tools (e.g. FieldCare)
	▪ Via Web browser (e.g. Microsoft Internet Explorer)
	▪ Also for device version with EtherNet/IP output:
	  ▪ Via Add-on Profile Level 3 for automation system from Rockwell Automation
	  ▪ Via Electronic Data Sheet (EDS)
	▪ Also for device version with PROFIBUS DP output:
	Via PDM driver for Siemens automation system

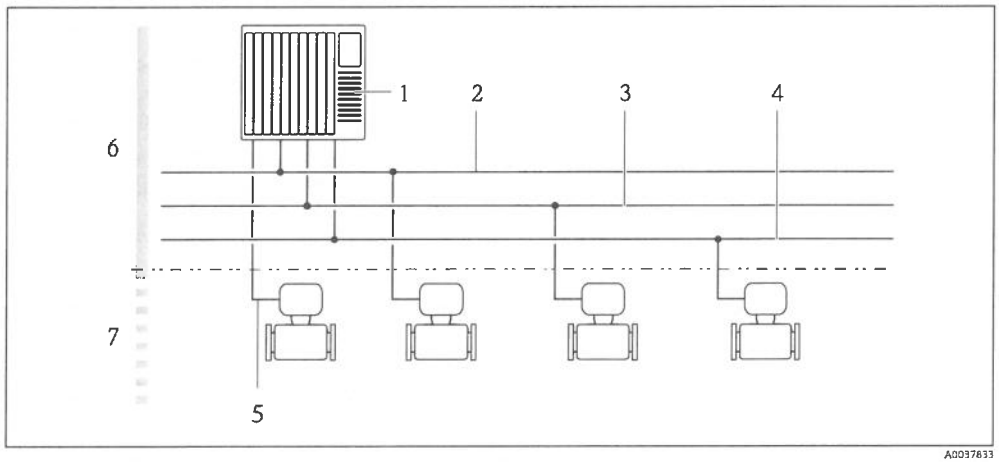
Sensor

Promag W *Lap joint flange, lap joint flange, stamped plate or fixed flange with aluminum half-shell housing: DN 25 to 300 (1 to 12")*  A0017040	▪ Nominal diameter range: DN 25 to 2400 (1 to 90") ▪ Materials→ 🖹 83
Fixed flange with fully welded housing made of carbon steel: DN 25 to 300 (1 to 12")  A0022673	

Fixed flange with fully welded housing made of carbon steel: DN 350 to 2400 (14 to 90")



Equipment architecture



1 Possibilities for integrating measuring devices into a system

1 *Control system (e.g. PLC)*
2 *EtherNet/IP*
3 *PROFIBUS DP*
4 *Modbus RS485*
5 *4-20 mA HART, pulse/frequency/switch output*
6 *Non-hazardous area*
7 *Non-hazardous area and Zone 2/Div. 2*

Safety

IT security

Our warranty is valid only if the device is installed and used as described in the Operating Instructions. The device is equipped with security mechanisms to protect it against any inadvertent changes to the settings.

IT security measures, which provide additional protection for the device and associated data transfer, must be implemented by the operators themselves in line with their security standards.

Device-specific IT security

The device offers a range of specific functions to support protective measures on the operator's side. These functions can be configured by the user and guarantee greater in-operation safety if used correctly. An overview of the most important functions is provided in the following section.

Protecting access via hardware write protection

Write access to the device parameters via the local display or operating tool (e.g. FieldCare, DeviceCare) can be disabled via a write protection switch (DIP switch on the motherboard). When hardware write protection is enabled, only read access to the parameters is possible.

Hardware write protection is disabled when the device is delivered.

Protecting access via a password

Different passwords are available to protect write access to the device parameters or access to the device via the WLAN interface.

- User-specific access code
  Protect write access to the device parameters via the local display, Web browser or operating tool (e.g. FieldCare, DeviceCare). Access authorization is clearly regulated through the use of a user-specific access code.
- WLAN passphrase
  The network key protects a connection between an operating unit (e.g. notebook or tablet) and the device via the WLAN interface which can be ordered as an option.
- Infrastructure mode
  When the device is operated in infrastructure mode, the WLAN passphrase corresponds to the WLAN passphrase configured on the operator side.

User-specific access code

Write access to the device parameters via the local display or operating tool (e.g. FieldCare, DeviceCare) can be protected by the modifiable, user-specific access code.

WLAN passphrase: Operation as WLAN access point

A connection between an operating unit (e.g. notebook or tablet) and the device via the WLAN interface, which can be ordered as an optional extra, is protected by the network key. The WLAN authentication of the network key complies with the IEEE 802.11 standard.

When the device is delivered, the network key is pre-defined depending on the device. It can be changed via the **WLAN settings** submenu in the **WLAN passphrase** parameter.

Infrastructure mode

A connection between the device and WLAN access point is protected by means of an SSID and passphrase on the system side. Please contact the relevant system administrator for access.

General notes on the use of passwords

- The access code and network key supplied with the device should be changed during commissioning.
- Follow the general rules for generating a secure password when defining and managing the access code or network key.
- The user is responsible for the management and careful handling of the access code and network key.

Access via Web server

The device can be operated and configured via a Web browser with the integrated Web server. The connection is via the service interface (CDI-RJ45) or the WLAN interface. For device versions with the EtherNet/IP and PROFINET communication protocols, the connection can also be established via the terminal connection for signal transmission with EtherNet/IP or PROFINET (RJ45 connector).

The Web server is enabled when the device is delivered. The Web server can be disabled if necessary (e.g. after commissioning) via the **Web server functionality** parameter.

The device and status information can be hidden on the login page. This prevents unauthorized access to the information.

For detailed information on device parameters, see:
The "Description of Device Parameters" document → 98

Input

Measured variable

Direct measured variables

- Volume flow (proportional to induced voltage)
- Electrical conductivity

In custody transfer: only volume flow

Calculated measured variables

Mass flow

Measuring range

Typically v = 0.01 to 10 m/s (0.03 to 33 ft/s) with the specified accuracy

Electrical conductivity: ≥ 5 µS/cm for liquids in general

Flow characteristic values in SI units: DN 25 to 125 (1 to 4")

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.3/10 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 2 pulse/s)	Low flow cut off (v ~ 0.04 m/s)
[mm]	[in]	[dm³/min]	[dm³/min]	[dm³]	[dm³/min]
25	1	9 to 300	75	0.5	1
32	–	15 to 500	125	1	2
40	1 ½	25 to 700	200	1.5	3
50	2	35 to 1100	300	2.5	5
65	–	60 to 2000	500	5	8
80	3	90 to 3000	750	5	12
100	4	145 to 4700	1200	10	20
125	–	220 to 7500	1850	15	30

Flow characteristic values in SI units: DN 150 to 2400 (6 to 90")

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.3/10 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 2 pulse/s)	Low flow cut off (v ~ 0.04 m/s)
[mm]	[in]	[m³/h]	[m³/h]	[m³]	[m³/h]
150	6	20 to 600	150	0.025	2.5
200	8	35 to 1100	300	0.05	5
250	10	55 to 1700	500	0.05	7.5
300	12	80 to 2400	750	0.1	10
350	14	110 to 3300	1000	0.1	15
375	15	140 to 4200	1200	0.15	20
400	16	140 to 4200	1200	0.15	20
450	18	180 to 5400	1500	0.25	25
500	20	220 to 6600	2000	0.25	30
600	24	310 to 9600	2500	0.3	40
700	28	420 to 13500	3500	0.5	50
750	30	480 to 15000	4000	0.5	60
800	32	550 to 18000	4500	0.75	75
900	36	690 to 22500	6000	0.75	100
1000	40	850 to 28000	7000	1	125
–	42	950 to 30000	8000	1	125
1200	48	1250 to 40000	10000	1.5	150
–	54	1550 to 50000	13000	1.5	200
1400	–	1700 to 55000	14000	2	225
–	60	1950 to 60000	16000	2	250

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.3/10 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 2 pulse/s)	Low flow cut off (v ~ 0.04 m/s)
[mm]	[in]	[m³/h]	[m³/h]	[m³]	[m³/h]
1600	–	2200 to 70000	18000	2.5	300
–	66	2500 to 80000	20500	2.5	325
1800	72	2800 to 90000	23000	3	350
–	78	3300 to 100000	28500	3.5	450
2000	–	3400 to 110000	28500	3.5	450
–	84	3700 to 125000	31000	4.5	500
2200	–	4100 to 136000	34000	4.5	540
–	90	4300 to 143000	36000	5	570
2400	–	4800 to 162000	40000	5.5	650

Flow characteristic values in SI units: DN 50 to 300 (2 to 12") for order code for "Design", option C "Fixed flange, without inlet/outlet runs"

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.12/5 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 4 pulse/s)	Low flow cut off (v ~ 0.01 m/s)
[mm]	[in]	[m³/h]	[m³/h]	[m³]	[m³/h]
50	2	15 to 600 dm³/min	300 dm³/min	1.25 dm³	1.25 dm³/min
65	–	25 to 1000 dm³/min	500 dm³/min	2 dm³	2 dm³/min
80	3	35 to 1500 dm³/min	750 dm³/min	3 dm³	3.25 dm³/min
100	4	60 to 2400 dm³/min	1200 dm³/min	5 dm³	4.75 dm³/min
125	–	90 to 3700 dm³/min	1850 dm³/min	8 dm³	7.5 dm³/min
150	6	145 to 5400 dm³/min	2500 dm³/min	10 dm³	11 dm³/min
200	8	220 to 9400 dm³/min	5000 dm³/min	20 dm³	19 dm³/min
250	10	20 to 850	500	0.03	1.75
300	12	35 to 1300	750	0.05	2.75

Flow characteristic values in US units: 1 to 48" (DN 25 to 1200)

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.3/10 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 2 pulse/s)	Low flow cut off (v ~ 0.04 m/s)
[in]	[mm]	[gal/min]	[gal/min]	[gal]	[gal/min]
1	25	2.5 to 80	18	0.2	0.25
–	32	4 to 130	30	0.2	0.5
1 ½	40	7 to 185	50	0.5	0.75
2	50	10 to 300	75	0.5	1.25
–	65	16 to 500	130	1	2
3	80	24 to 800	200	2	2.5

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.3/10 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 2 pulse/s)	Low flow cut off (v ~ 0.04 m/s)
[in]	[mm]	[gal/min]	[gal/min]	[gal]	[gal/min]
4	100	40 to 1250	300	2	4
–	125	60 to 1950	450	5	7
6	150	90 to 2650	600	5	12
8	200	155 to 4850	1200	10	15
10	250	250 to 7500	1500	15	30
12	300	350 to 10600	2400	25	45
14	350	500 to 15000	3600	30	60
15	375	600 to 19000	4800	50	60
16	400	600 to 19000	4800	50	60
18	450	800 to 24000	6000	50	90
20	500	1000 to 30000	7500	75	120
24	600	1400 to 44000	10500	100	180
28	700	1900 to 60000	13500	125	210
30	750	2150 to 67000	16500	150	270
32	800	2450 to 80000	19500	200	300
36	900	3100 to 100000	24000	225	360
40	1000	3800 to 125000	30000	250	480
42	–	4200 to 135000	33000	250	600
48	1200	5500 to 175000	42000	400	600

Flow characteristic values in US units: 54 to 90" (DN 1400 to 2400)

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.3/10 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 2 pulse/s)	Low flow cut off (v ~ 0.04 m/s)
[in]	[mm]	[Mgal/d]	[Mgal/d]	[Mgal]	[Mgal/d]
54	–	9 to 300	75	0.0005	1.3
–	1400	10 to 340	85	0.0005	1.3
60	–	12 to 380	95	0.0005	1.3
–	1600	13 to 450	110	0.0008	1.7
66	–	14 to 500	120	0.0008	2.2
72	1800	16 to 570	140	0.0008	2.6
78	–	18 to 650	175	0.0010	3.0
–	2000	20 to 700	175	0.0010	2.9
84	–	24 to 800	190	0.0011	3.2
–	2200	26 to 870	210	0.0012	3.4
90	–	27 to 910	220	0.0013	3.6
–	2400	31 to 1030	245	0.0014	4.1

Flow characteristic values in US units: 2 to 12" (DN 50 to 300) for order code for "Design", option C "Fixed flange, without inlet/outlet runs"

Nominal diameter		Recommended flow	Factory settings		
		min./max. full scale value (v ~ 0.12/5 m/s)	Full scale value current output (v ~ 2.5 m/s)	Pulse value (~ 4 pulse/s)	Low flow cut off (v ~ 0.01 m/s)
[in]	[mm]	[gal/min]	[gal/min]	[gal]	[gal/min]
2	50	4 to 160	75	0.3	0.35
–	65	7 to 260	130	0.5	0.6
3	80	10 to 400	200	0.8	0.8
4	100	16 to 650	300	1.2	1.25
–	125	24 to 1000	450	1.8	2
6	150	40 to 1400	600	2.5	3
8	200	60 to 2500	1200	5	5
10	250	90 to 3700	1500	6	8
12	300	155 to 5700	2400	9	12

Recommended measuring range

Flow limit → 48

For custody transfer, the applicable approval determines the permitted measuring range, the pulse value and the low flow cut off.

Operable flow range

Over 1000 : 1

For custody transfer, the operable flow range is 100 : 1 to 630 : 1, depending on the nominal diameter. Further details are specified by the applicable approval.

Input signal

External measured values

Various pressure transmitters and temperature measuring devices can be ordered from Endress +Hauser: see "Accessories" section → 97

It is recommended to read in external measured values to calculate the following measured variables: Mass flow

HART protocol

The measured values are written from the automation system to the measuring device via the HART protocol. The pressure transmitter must support the following protocol-specific functions:
- HART protocol
- Burst mode

Digital communication

The measured values can be written from the automation system to the measuring via:
- PROFIBUS DP
- Modbus RS485
- EtherNet/IP

Status input

Maximum input values	▪ DC 30 V ▪ 6 mA
Response time	Adjustable: 5 to 200 ms

Input signal level	▪ Low signal: DC –3 to +5 V ▪ High signal: DC 12 to 30 V
Assignable functions	▪ Off ▪ Reset totalizers 1-3 separately ▪ Reset all totalizers ▪ Flow override

Output

Output signal

Current output

Current output	Can be set as: ▪ 4-20 mA NAMUR ▪ 4-20 mA US ▪ 4-20 mA HART ▪ 0-20 mA
Maximum output values	▪ DC 24 V (no flow) ▪ 22.5 mA
Load	0 to 700 Ω
Resolution	0.5 µA
Damping	Adjustable: 0.07 to 999 s
Assignable measured variables	▪ Volume flow ▪ Mass flow ▪ Flow velocity ▪ Conductivity ▪ Electronic temperature

Pulse/frequency/switch output

Function	▪ With the order code for "Output; Input", option **H**: output 2 can be set as a pulse or frequency output ▪ With the order code for "Output; Input", option **I**: output 2 and 3 can be set as a pulse, frequency or switch output ▪ With the order code for "Output; Input", option **J**: output 2 firmly assigned as certified pulse output
Version	Passive, open collector
Maximum input values	▪ DC 30 V ▪ 250 mA
Voltage drop	For 25 mA: ≤ DC 2 V
Pulse output	
Pulse width	Adjustable: 0.05 to 2 000 ms
Maximum pulse rate	10 000 Impulse/s
Pulse value	Adjustable
Assignable measured variables	▪ Volume flow ▪ Mass flow
Frequency output	
Output frequency	Adjustable: 0 to 12 500 Hz
Damping	Adjustable: 0 to 999 s
Pulse/pause ratio	1:1

Assignable measured variables	▪ Volume flow ▪ Mass flow ▪ Conductivity ▪ Flow velocity ▪ Electronic temperature
Switch output	
Switching behavior	Binary, conductive or non-conductive
Switching delay	Adjustable: 0 to 100 s
Number of switching cycles	Unlimited

Assignable functions	▪ Off
	▪ On
	▪ Diagnostic behavior
	▪ Limit value:
	  ▪ Off
	  ▪ Volume flow
	  ▪ Mass flow
	  ▪ Conductivity
	  ▪ Flow velocity
	  ▪ Totalizer 1-3
	  ▪ Electronic temperature
	▪ Flow direction monitoring
	▪ Status
	  ▪ Empty pipe detection
	  ▪ Low flow cut off

PROFIBUS DP

Signal encoding	NRZ code
Data transfer	9.6 kBaud...12 MBaud

Modbus RS485

Physical interface	In accordance with EIA/TIA-485-A standard
Terminating resistor	Integrated, can be activated via DIP switch on the transmitter electronics module

EtherNet/IP

Standards	In accordance with IEEE 802.3

Signal on alarm

Depending on the interface, failure information is displayed as follows:

Current output 4 to 20 mA

4 to 20 mA

Failure mode	Choose from: ▪ 4 to 20 mA in accordance with NAMUR recommendation NE 43 ▪ 4 to 20 mA in accordance with US ▪ Min. value: 3.59 mA ▪ Max. value: 22.5 mA ▪ Freely definable value between: 3.59 to 22.5 mA ▪ Actual value ▪ Last valid value

0 to 20 mA

Failure mode	Choose from: ▪ Maximum alarm: 22 mA ▪ Freely definable value between: 0 to 22.5 mA

HART current output

Device diagnostics	Device condition can be read out via HART Command 48

Pulse/frequency/switch output

Pulse output	
Failure mode	Choose from: ▪ Actual value ▪ No pulses
Frequency output	
Failure mode	Choose from: ▪ Actual value ▪ 0 Hz ▪ Defined value: 0 to 12 500 Hz
Switch output	
Failure mode	Choose from: ▪ Current status ▪ Open ▪ Closed

PROFIBUS DP

Status and alarm messages	Diagnostics in accordance with PROFIBUS PA Profile 3.02

Modbus RS485

Failure mode	Choose from: ▪ NaN value instead of current value ▪ Last valid value

EtherNet/IP

Device diagnostics	Device condition can be read out in Input Assembly

Local display

Plain text display	With information on cause and remedial measures
Backlight	Red backlighting indicates a device error.

Status signal as per NAMUR recommendation NE 107

Interface/protocol

- Via digital communication:
  - HART protocol
  - PROFIBUS DP
  - Modbus RS485
  - EtherNet/IP
- Via service interface
  - CDI-RJ45 service interface
  - WLAN interface

Plain text display	With information on cause and remedial measures

Additional information on remote operation → 87

Web browser

Plain text display	With information on cause and remedial measures

Light emitting diodes (LED)

Status information	Status indicated by various light emitting diodes The following information is displayed depending on the device version: • Supply voltage active • Data transmission active • Device alarm/error has occurred • EtherNet/IP network available • EtherNet/IP connection established

Low flow cut off

The switch points for low flow cut off are user-selectable.

Galvanic isolation

The following connections are galvanically isolated from each other:
- Inputs
- Outputs
- Power supply

Protocol-specific data

HART

Manufacturer ID	0x11
Device type ID	0x69
HART protocol revision	7
Device description files (DTM, DD)	Information and files under: www.endress.com
HART load	Min. 250 Ω

Dynamic variables	Read out the dynamic variables: HART command 3 The measured variables can be freely assigned to the dynamic variables. **Measured variables for PV (primary dynamic variable)** ▪ Off ▪ Volume flow ▪ Mass flow ▪ Conductivity ▪ Flow velocity ▪ Electronic temperature **Measured variables for SV, TV, QV (secondary, tertiary and quaternary dynamic variable)** ▪ Volume flow ▪ Mass flow ▪ Conductivity ▪ Flow velocity ▪ Electronic temperature ▪ Totalizer 1 ▪ Totalizer 2 ▪ Totalizer 3
Device variables	Read out the device variables: HART command 9 The device variables are permanently assigned. A maximum of 8 device variables can be transmitted: ▪ 0 = volume flow ▪ 1 = mass flow ▪ 2 = conductivity ▪ 3 = flow velocity ▪ 4 = electronic temperature ▪ 5 = totalizer 1 ▪ 6 = totalizer 2 ▪ 7 = totalizer 3

PROFIBUS DP

Manufacturer ID	0x11
Ident number	0x1562
Profile version	3.02
Device description files (GSD, DTM, DD)	Information and files under: ▪ www.endress.com ▪ www.profibus.org
Output values (from measuring device to automation system)	**Analog input 1 to 4** ▪ Mass flow ▪ Volume flow ▪ Flow velocity ▪ Conductivity ▪ Electronic temperature **Digital input 1 to 2** ▪ Empty pipe detection ▪ Low flow cut off ▪ Verification status **Totalizer 1 to 3** ▪ Mass flow ▪ Volume flow

Input values
(from automation system to measuring device)
	Analog output 1 (fixed assignment)
	External density
	Digital output 1 to 2 (fixed assignment)
	▪ Digital output 1: switch positive zero return on/off
	▪ Digital output 2: start verification
	Totalizer 1 to 3
	▪ Totalize
	▪ Reset and hold
	▪ Preset and hold
	▪ Stop
	▪ Operating mode configuration:
	  ▪ Net flow total
	  ▪ Forward flow total
	  ▪ Reverse flow total

Supported functions	▪ Identification & Maintenance Simplest device identification on the part of the control system and nameplate ▪ PROFIBUS upload/download Reading and writing parameters is up to ten times faster with PROFIBUS upload/download ▪ Condensed status Simplest and self-explanatory diagnostic information by categorizing diagnostic messages that occur
Configuration of the device address	▪ DIP switches on the I/O electronics module ▪ Via operating tools (e.g. FieldCare)

Modbus RS485

Protocol	Modbus Applications Protocol Specification V1.1
Device type	Slave
Slave address range	1 to 247
Broadcast address range	0
Function codes	▪ 03: Read holding register ▪ 04: Read input register ▪ 06: Write single registers ▪ 08: Diagnostics ▪ 16: Write multiple registers ▪ 23: Read/write multiple registers
Broadcast messages	Supported by the following function codes: ▪ 06: Write single registers ▪ 16: Write multiple registers ▪ 23: Read/write multiple registers
Supported baud rate	▪ 1200 BAUD ▪ 2400 BAUD ▪ 4800 BAUD ▪ 9600 BAUD ▪ 19200 BAUD ▪ 38400 BAUD ▪ 57600 BAUD ▪ 115200 BAUD
Data transfer mode	▪ ASCII ▪ RTU
Data access	Each device parameter can be accessed via Modbus RS485. For detailed information on "Modbus RS485 register information", see the Description of Device Parameters → 98

EtherNet/IP

Protocol	▪ The CIP Networks Library Volume 1: Common Industrial Protocol ▪ The CIP Networks Library Volume 2: EtherNet/IP Adaptation of CIP		
Communication type	▪ 10Base-T ▪ 100Base-TX		
Device profile	Generic device (product type: 0x2B)		
Manufacturer ID	0x49E		
Device type ID	0x1067		
Baud rates	Automatic $^{10}/_{100}$ Mbit with half-duplex and full-duplex detection		
Polarity	Auto-polarity for automatic correction of crossed TxD and RxD pairs		
Supported CIP connections	Max. 3 connections		
Explicit connections	Max. 6 connections		
I/O connections	Max. 6 connections (scanner)		
Configuration options for measuring device	▪ DIP switches on the electronics module for IP addressing ▪ Manufacturer-specific software (FieldCare) ▪ Custom Add-on Profile for Rockwell Automation control systems ▪ Web browser ▪ Electronic Data Sheet (EDS) integrated in the measuring device		
Configuration of the EtherNet interface	▪ Speed: 10 MBit, 100 MBit, auto (factory setting) ▪ Duplex: half-duplex, full-duplex, auto (factory setting)		
Configuration of the device address	▪ DIP switches on the electronics module for IP addressing (last octet) ▪ DHCP ▪ Manufacturer-specific software (FieldCare) ▪ Custom Add-on Profile for Rockwell Automation control systems ▪ Web browser ▪ EtherNet/IP tools, e.g. RSLinx (Rockwell Automation)		
Device Level Ring (DLR)	No		
Fix Input			
RPI	5 ms to 10 s (factory setting: 20 ms)		
Exclusive Owner Multicast		Instance	Size [byte]
	Instance configuration:	0x68	398
	O → T configuration:	0x66	56
	T → O configuration:	0x64	32
Exclusive Owner Multicast		Instance	Size [byte]
	Instance configuration:	0x69	-
	O → T configuration:	0x66	56
	T → O configuration:	0x64	32
Input only Multicast		Instance	Size [byte]
	Instance configuration:	0x68	398
	O → T configuration:	0xC7	-
	T → O configuration:	0x64	32
Input only Multicast		Instance	Size [byte]
	Instance configuration:	0x69	-
	O → T configuration:	0xC7	-
	T → O configuration:	0x64	32

Input Assembly	▪ Current device diagnostics ▪ Volume flow ▪ Mass flow ▪ Conductivity ▪ Totalizer 1 ▪ Totalizer 2 ▪ Totalizer 3		
Configurable Input			
RPI	5 ms to 10 s (factory setting: 20 ms)		
Exclusive Owner Multicast		Instance	Size [byte]
	Instance configuration:	0x68	398
	O → T configuration:	0x66	56
	T → O configuration:	0x65	88
Exclusive Owner Multicast		Instance	Size [byte]
	Instance configuration:	0x69	-
	O → T configuration:	0x66	56
	T → O configuration:	0x65	88
Input only Multicast		Instance	Size [byte]
	Instance configuration:	0x68	398
	O → T configuration:	0xC7	-
	T → O configuration:	0x65	88
Input only Multicast		Instance	Size [byte]
	Instance configuration:	0x69	-
	O → T configuration:	0xC7	-
	T → O configuration:	0x65	88
Configurable Input Assembly	▪ Volume flow ▪ Mass flow ▪ Electronic temperature ▪ Conductivity ▪ Totalizer 1 to 3 ▪ Flow velocity ▪ Volume flow unit ▪ Mass flow unit ▪ Temperature unit ▪ Conductivity unit ▪ Unit totalizer 1-3 ▪ Flow velocity unit ▪ Verification result ▪ Verification status The range of options increases if the measuring device has one or more application packages.		
Fix Output			
Output Assembly	▪ Activation of reset totalizers 1-3 ▪ Activation of reference density compensation ▪ Reset totalizers 1-3 ▪ External density ▪ Density unit ▪ Activation verification ▪ Start verification		

Configuration	

Configuration Assembly	Only the most common configurations are listed below.
	▪ Software write protection
	▪ Mass flow unit
	▪ Mass unit
	▪ Volume flow unit
	▪ Volume unit
	▪ Density unit
	▪ Conductivity
	▪ Temperature unit
	▪ Totalizer 1-3:
	  ▪ Assignment
	  ▪ Unit
	  ▪ Operating mode
	  ▪ Failure mode
	▪ Alarm delay

Power supply

Terminal assignment

Transmitter: 0-20 mA/4-20 mA HART

The sensor can be ordered with terminals.

Connection methods available		Possible options for order code "Electrical connection"
Outputs	**Power supply**	
Terminals	Terminals	▪ Option **A**: coupling M20x1 ▪ Option **B**: thread M20x1 ▪ Option **C**: thread G ½" ▪ Option **D**: thread NPT ½"

Supply voltage

Order code "Power supply"	Terminal numbers	terminal voltage		Frequency range
Option **L** (wide range power unit)	1 (L+/L), 2 (L-/N)	DC 24 V	±25%	–
		AC 24 V	±25%	50/60 Hz, ±4 Hz
		AC 100 to 240 V	−15 to +10%	50/60 Hz, ±4 Hz

Signal transmission 0-20 mA/4-20 mA HART and additional outputs and inputs

Order code for "Output" and "Input"	Terminal numbers							
	Output 1		Output 2		Output 3		Input	
	26 (+)	27 (-)	24 (+)	25 (-)	22 (+)	23 (-)	20 (+)	21 (-)
Option **H**	▪ 4-20 mA HART (active) ▪ 0-20 mA (active)		Pulse/frequency output (passive)		Switch output (passive)		-	
Option **I**	▪ 4-20 mA HART (active) ▪ 0-20 mA (active)		Pulse/frequency/ switch output (passive)		Pulse/frequency/ switch output (passive)		Status input	
Option **J**	▪ 4-20 mA HART (active) ▪ 0-20 mA (active)		Permanently assigned: Pulse output adjusted (passive)		Pulse/frequency/ switch output (passive)		Status input	

Transmitter: PROFIBUS DP

The sensor can be ordered with terminals.

Connection methods available		Possible options for order code "Electrical connection"
Outputs	**Power supply**	
Terminals	Terminals	▪ Option **A**: coupling M20x1 ▪ Option **B**: thread M20x1 ▪ Option **C**: thread G ½" ▪ Option **D**: thread NPT ½"

Supply voltage

Order code "Power supply"	Terminal numbers	terminal voltage		Frequency range
Option **L** (wide range power unit)	1 (L+/L), 2 (L-/N)	DC 24 V	±25%	–
		AC 24 V	±25%	50/60 Hz, ±4 Hz
		AC 100 to 240 V	−15 to +10%	50/60 Hz, ±4 Hz

PROFIBUS DP signal transmission

Order code for "Output" and "Input"	Terminal numbers	
	26 (RxD/TxD-P)	**27 (RxD/TxD-N)**
Option **L**	B	A
Order code for "Output": Option L: PROFIBUS DP, for use in non-hazardous areas and Zone 2/div. 2		

Transmitter: Modbus RS485

The sensor can be ordered with terminals.

Connection methods available		Possible options for order code "Electrical connection"
Outputs	**Power supply**	
Terminals	Terminals	▪ Option **A**: coupling M20x1 ▪ Option **B**: thread M20x1 ▪ Option **C**: thread G ½" ▪ Option **D**: thread NPT ½"

Supply voltage

Order code "Power supply"	Terminal numbers	terminal voltage		Frequency range
Option **L** (wide range power unit)	1 (L+/L), 2 (L-/N)	DC 24 V	±25%	–
		AC 24 V	±25%	50/60 Hz, ±4 Hz
		AC 100 to 240 V	−15 to +10%	50/60 Hz, ±4 Hz

Signal transmission Modbus RS485

Order code for "Output" and "Input"	Terminal numbers	
	26 (+)	**27 (-)**
Option **M**	B	A

Transmitter: EtherNet/IP

The transmitter can be ordered with terminals or a device plug.

Connection methods available		Possible options for order code "Electrical connection"
Outputs	**Power supply**	
EtherNet/IP (RJ45 connector)	Terminals	Option **D**: thread NPT ½"
Device plug → 🖹 23	Terminals	▪ Option **L**: plug M12x1 + thread NPT ½" ▪ Option **N**: plug M12x1 + coupling M20 ▪ Option **P**: plug M12x1 + thread G ½" ▪ Option **U**: plug M12x1 + thread M20

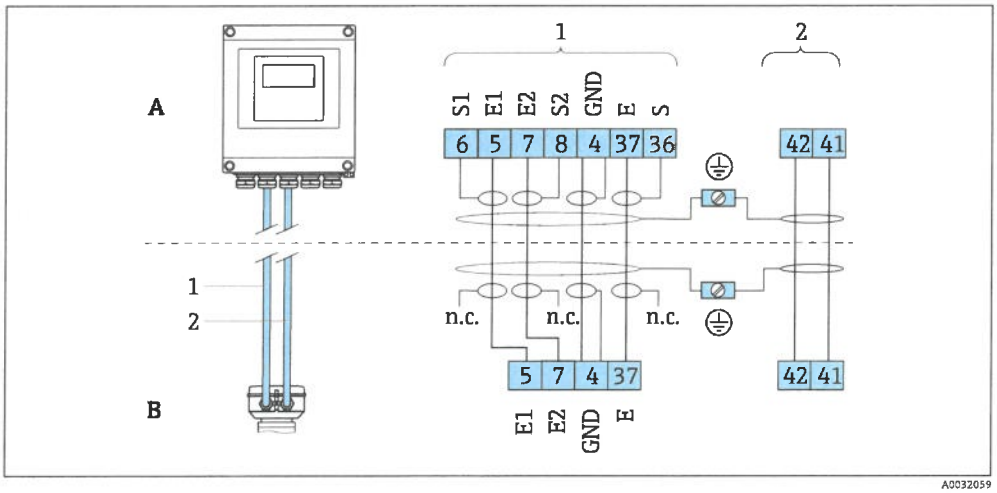
Supply voltage

Order code "Power supply"	Terminal numbers	terminal voltage		Frequency range
Option **L** (wide range power unit)	1 (L+/L), 2 (L-/N)	DC 24 V	±25%	–
		AC 24 V	±25%	50/60 Hz, ±4 Hz
		AC 100 to 240 V	−15 to +10%	50/60 Hz, ±4 Hz

EtherNet/IP signal transmission

Order code for "Output"	Connection via
Option **N**	EtherNet/IP: RJ45 or M12 connector

Remote version



🖼 2 *Remote version terminal assignment*

A Transmitter wall-mount housing
B Sensor connection housing
1 Electrode cable
2 Coil current cable
n.c. Not connected, insulated cable shields

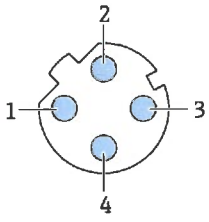
Terminal No. and cable colors: 6/5 = brown; 7/8 = white; 4 = green; 36/37 = yellow

Pin assignment, device plug

Order codes for the M12x1 connectors, see the "Order code for electrical connection" column: EtherNet/IP → 🖹 23

EtherNet/IP

Device plug for signal transmission (device side)



Pin		Assignment	Coding	Plug/socket
1	+	Tx	D	Socket
2	+	Rx		
3	-	Tx		
4	-	Rx		

Recommended plug:
- Binder, series 763, part no. 99 3729 810 04
- Phoenix, part no. 1543223 SACC-M12MSD-4Q
- The device plug is not permitted in the hazardous area, Class I Division 2. The device plug may only be used in the non-hazardous area (General Purpose).

Supply voltage

Transmitter

Order code for "Power supply"	terminal voltage		Frequency range
Option **L**	DC 24 V	±25%	-
	AC 24 V	±25%	50/60 Hz, ±4 Hz
	AC 100 to 240 V	-15 to +10%	50/60 Hz, ±4 Hz

Power consumption

Order code for "Output"	Maximum power consumption
Option **H**: 4-20mA HART, pulse/frequency/switch output, switch output	30 VA/8 W
Option **I**: 4-20mA HART, 2 x pulse/frequency/switch output, status input	30 VA/8 W
Option **J**: 4-20mA HART, certified pulse output, pulse/frequency/switch output, status input	30 VA/8 W
Option **L**: PROFIBUS DP	30 VA/8 W
Option **M**: Modbus RS485	30 VA/8 W
Option **N**: EtherNet/IP	30 VA/8 W

Current consumption

Transmitter

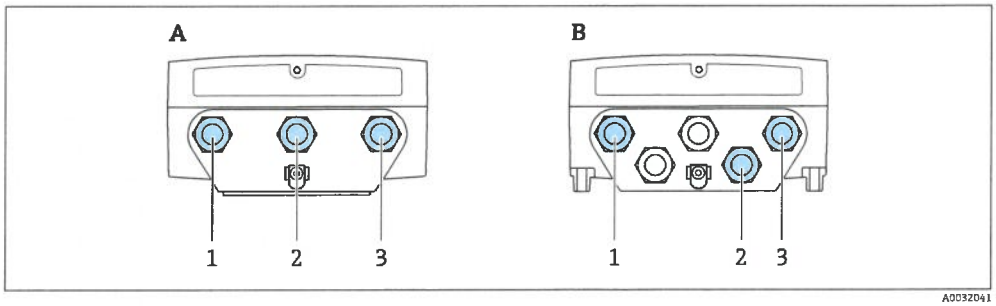
Order code for "Power supply"	Maximum Current consumption	Maximum switch-on current
Option **L**: AC 100 to 240 V	145 mA	25 A (< 5 ms)
Option **L**: AC/DC 24 V	350 mA	27 A (< 5 ms)

Power supply failure

- Totalizers stop at the last value measured.
- Depending on the device version, the configuration is retained in the device memoryor in the pluggable data memory (HistoROM DAT).
- Error messages (incl. total operated hours) are stored.

Electrical connection

Connecting the transmitter

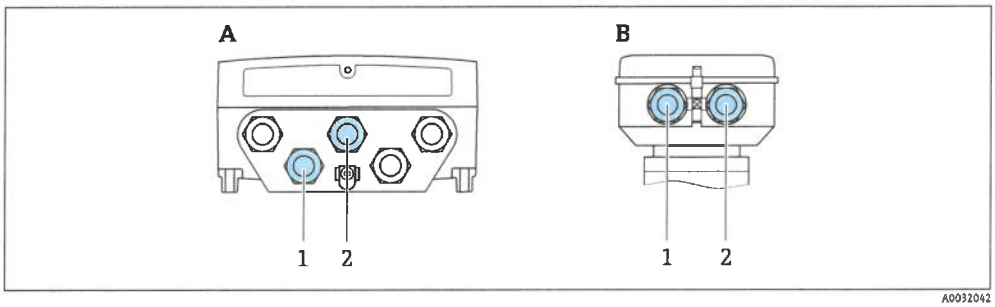


3 *Supply voltage and signal transmission connection*

A Compact version
B Remote version wall-mount housing
1 Cable entry for supply voltage
2 Cable entry for signal transmission
3 Cable entry for signal transmission

Remote version connection

Connecting cable



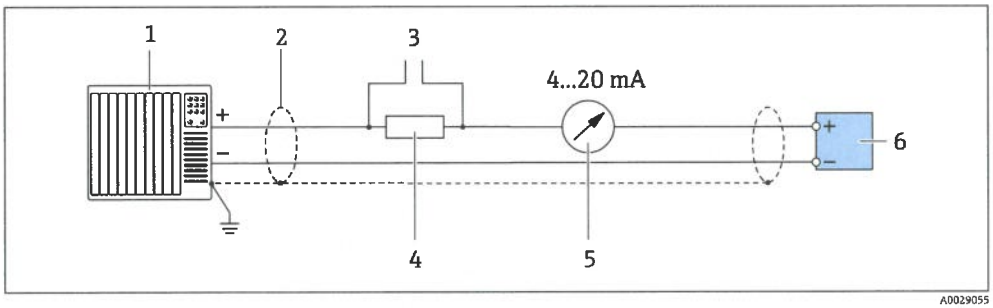
4 *Connecting cable connection: electrode and coil current cable*

A Transmitter wall-mount housing
B Sensor connection housing
1 Electrode cable
2 Coil current cable

- Fix the cable run or route it in an armored conduit.
  Cable movements can influence the measuring signal especially in the case of low fluid conductivities.
- Route the cable well clear of electrical machines and switching elements.
- Ensure potential equalization between sensor and transmitter .

Connection examples

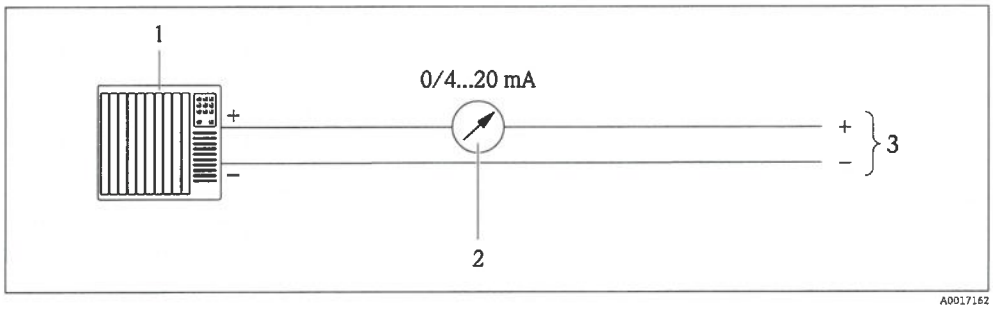
Current output 4 to 20 mA HART



5 *Connection example for 4 to 20 mA HART current output (active)*

1 *Automation system with current input (e.g. PLC)*
2 *Cable shield provided at one end. The cable shield must be grounded at both ends to comply with EMC requirements; observe cable specifications → 31*
3 *Connection for HART operating devices → 87*
4 *Resistor for HART communication (≥ 250 Ω): observe maximum load → 13*
5 *Analog display unit: observe maximum load → 13*
6 *Transmitter*

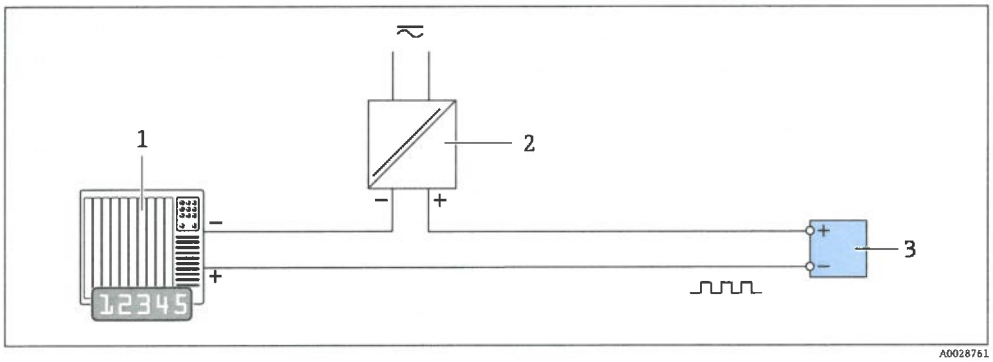
Current output 4-20 mA



6 *Connection example for 0-20 mA current output (active) and 4-20 mA current output (active)*

1 *Automation system with current input (e.g. PLC)*
2 *Analog display unit: observe maximum load*
3 *Transmitter*

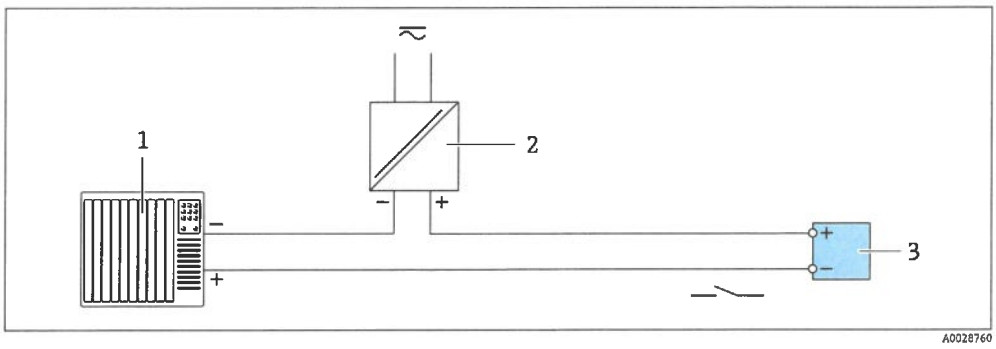
Pulse/frequency output



7 *Connection example for pulse/frequency output (passive)*

1 *Automation system with pulse/frequency input (e.g. PLC)*
2 *Power supply*
3 *Transmitter: Observe input values → 13*

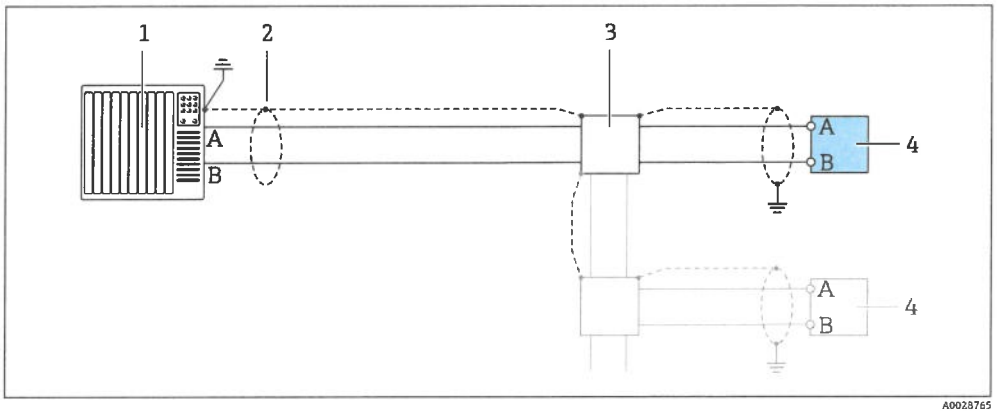
Switch output



8 Connection example for switch output (passive)

1 *Automation system with switch input (e.g. PLC)*
2 *Power supply*
3 *Transmitter: Observe input values → 13*

PROFIBUS DP

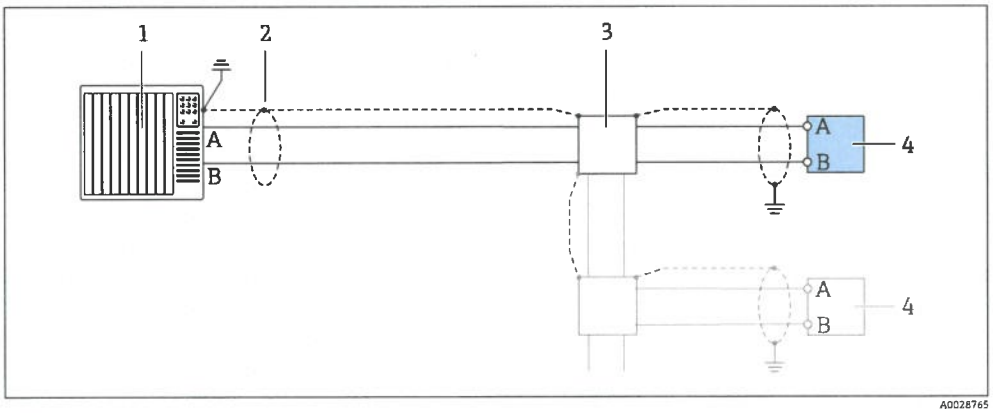


9 Connection example for PROFIBUS DP, non-hazardous area and Zone 2/Div. 2

1 *Control system (e.g. PLC)*
2 *Cable shield provided at one end. The cable shield must be grounded at both ends to comply with EMC requirements; observe cable specifications*
3 *Distribution box*
4 *Transmitter*

If baud rates > 1.5 MBaud an EMC cable entry must be used and the cable shield must continue as far as the terminal wherever possible.

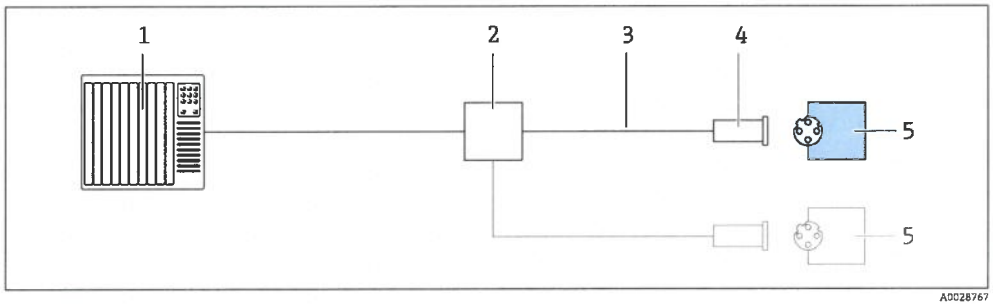
Modbus RS485



10 *Connection example for Modbus RS485, non-hazardous area and Zone 2/Div. 2*

1 *Control system (e.g. PLC)*
2 *Cable shield provided at one end. The cable shield must be grounded at both ends to comply with EMC requirements; observe cable specifications*
3 *Distribution box*
4 *Transmitter*

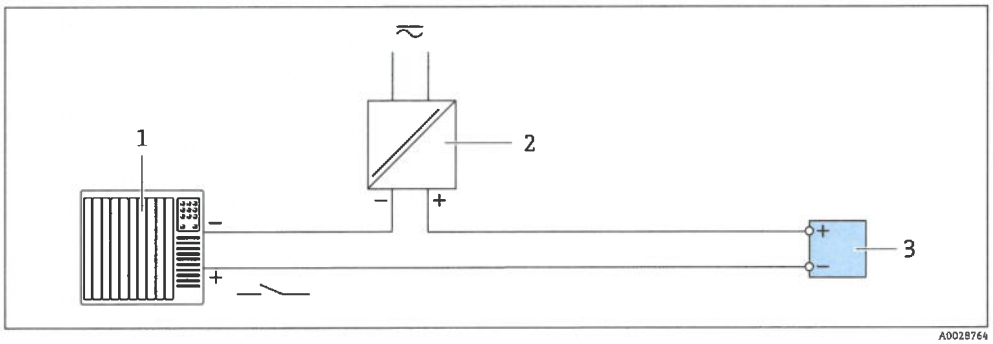
EtherNet/IP



11 *Connection example for EtherNet/IP*

1 *Control system (e.g. PLC)*
2 *Ethernet switch*
3 *Observe cable specifications*
4 *Device plug*
5 *Transmitter*

Status input



12 *Connection example for status input*

1 *Automation system with status output (e.g. PLC)*
2 *Power supply*
3 *Transmitter*

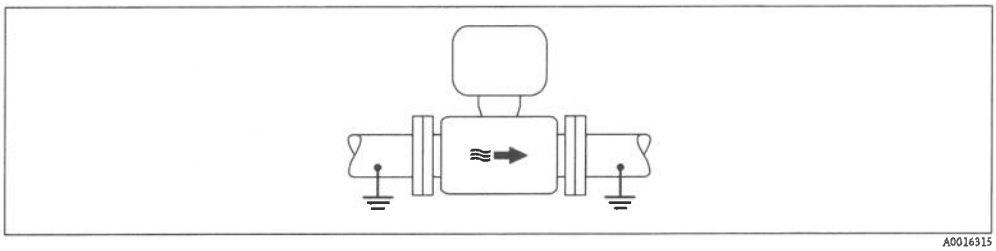
Potential equalization

Requirements

Please consider the following to ensure correct measurement:
- Same electrical potential for the fluid and sensor
- Remote version: same electrical potential for the sensor and transmitter
- Company-internal grounding concepts
- Pipe material and grounding

Connection example, standard scenario

Metal, grounded pipe



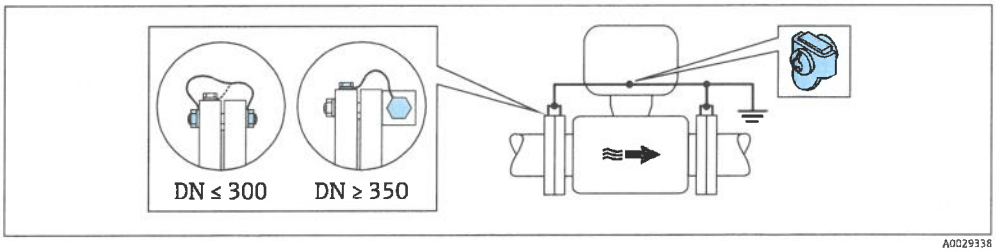
13 *Potential equalization via measuring tube*

Connection example in special situations

Unlined and ungrounded metal pipe

This connection method also applies in situations where:
- The customary potential equalization is not used
- Equalizing currents are present

Ground cable	Copper wire, at least 6 mm² (0.0093 in²)



14 *Potential equalization via ground terminal and pipe flanges*

Note the following when installing:
- Connect both sensor flanges to the pipe flange via a ground cable and ground them.
- Connect the connection housing of the transmitter or sensor to ground potential by means of the ground terminal provided for the purpose. To mount the ground cable:
  - If DN ≤ 300 (12"): Mount the ground cable directly on the conductive flange coating of the sensor with the flange screws.
  - If DN ≥ 350 (14"): Mount the ground cable directly on the metal transport bracket.

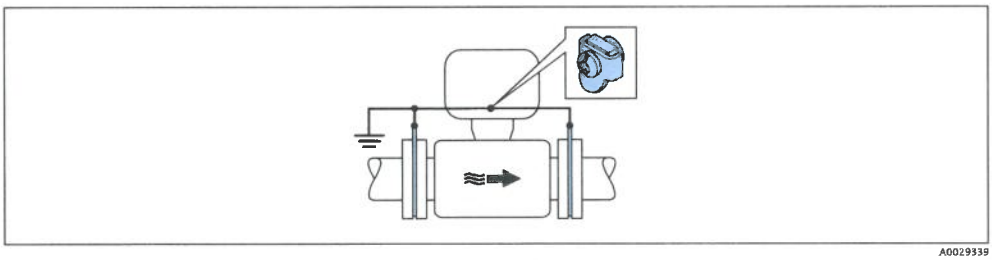
For remote device versions, the ground terminal in the example always refers to the sensor and **not** to the transmitter.

You can order the necessary ground cable from Endress+Hauser: .

Plastic pipe or pipe with insulating liner

This connection method also applies in situations where:
- The customary potential equalization is not used
- Equalizing currents are present

Ground cable	Copper wire, at least 6 mm² (0.0093 in²)



15 *Potential equalization via ground terminal and ground disks*

Note the following when installing:
The ground disks must be connected to the ground terminal via the ground cable and be connected to ground potential.

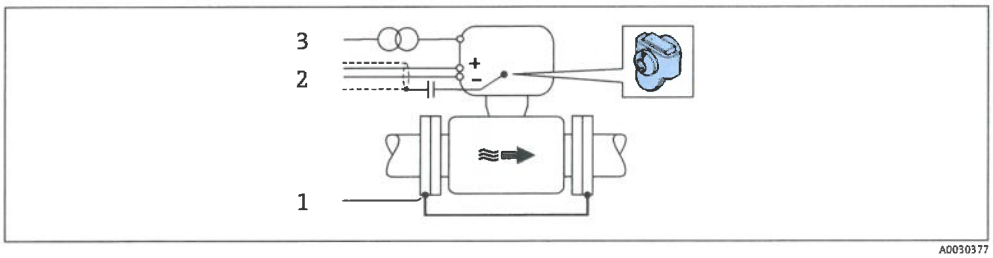
For remote device versions, the ground terminal in the example always refers to the sensor and **not** to the transmitter.

The ground cable and ground disks can be ordered from Endress+Hauser → 96.

Pipe with a cathodic protection unit

This connection method is only used if the following two conditions are met:
- Metal pipe without liner or pipe with electrically conductive liner
- Cathodic protection is integrated in the personal protection equipment

Ground cable	Copper wire, at least 6 mm² (0.0093 in²)



1 *Connection of the two flanges of the pipe via a ground cable*
2 *Signal line shielding via a capacitor*
3 *Measuring device connected to power supply such that it is floating in relation to the protective ground (isolation transformer)*

Note the following when installing:
The sensor is installed in the pipe in a way that provides electrical insulation.

For remote device versions, the ground terminal in the example always refers to the sensor and **not** to the transmitter.

You can order the necessary ground cable from Endress+Hauser: .

terminals

Transmitter
- Supply voltage cable: plug-in spring terminals for wire cross-sections 0.5 to 2.5 mm² (20 to 14 AWG)
- Signal cable: plug-in spring terminals for wire cross-sections 0.5 to 2.5 mm² (20 to 14 AWG)
- Electrode cable: spring terminals for wire cross-sections 0.5 to 2.5 mm² (20 to 14 AWG)
- Coil current cable: spring terminals for wire cross-sections 0.5 to 2.5 mm² (20 to 14 AWG)

Sensor connection housing
Spring terminals for wire cross-sections0.5 to 2.5 mm² (20 to 14 AWG)

Cable entries

Cable entry thread
- M20 x 1.5
- Via adapter:
  - NPT ½"
  - G ½"

Cable gland
- For standard cable: M20 × 1.5 with cable Φ6 to 12 mm (0.24 to 0.47 in)
- For reinforced cable: M20 × 1.5 with cable Φ9.5 to 16 mm (0.37 to 0.63 in)

If metal cable entries are used, use a grounding plate.

Cable specification

Permitted temperature range
- The installation guidelines that apply in the country of installation must be observed.
- The cables must be suitable for the minimum and maximum temperatures to be expected.

Power supply cable

Standard installation cable is sufficient.

Signal cable

Current output 0/4 to 20 mA

Standard installation cable is sufficient.

Current output 4 to 20 mA HART

A shielded cable is recommended. Observe grounding concept of the plant.

Pulse/frequency/switch output

Standard installation cable is sufficient.

Status input

Standard installation cable is sufficient.

PROFIBUS DP

The IEC 61158 standard specifies two types of cable (A and B) for the bus line which can be used for every transmission rate. Cable type A is recommended.

Cable type	A
Characteristic impedance	135 to 165 Ω at a measuring frequency of 3 to 20 MHz
Cable capacitance	< 30 pF/m
Wire cross-section	> 0.34 mm² (22 AWG)
Cable type	Twisted pairs
Loop resistance	≤110 Ω/km
Signal damping	Max. 9 dB over the entire length of the cable cross-section
Shield	Copper braided shielding or braided shielding with foil shield. When grounding the cable shield, observe the grounding concept of the plant.

For further information on planning and installing PROFIBUS networks see:

Operating Instructions "PROFIBUS DP/PA: Guidelines for planning and commissioning" (BA00034S)

Modbus RS485

The EIA/TIA-485 standard specifies two types of cable (A and B) for the bus line which can be used for every transmission rate. Cable type A is recommended.

Cable type	A
Characteristic impedance	135 to 165 Ω at a measuring frequency of 3 to 20 MHz
Cable capacitance	< 30 pF/m
Wire cross-section	> 0.34 mm² (22 AWG)
Cable type	Twisted pairs
Loop resistance	≤110 Ω/km
Signal damping	Max. 9 dB over the entire length of the cable cross-section
Shield	Copper braided shielding or braided shielding with foil shield. When grounding the cable shield, observe the grounding concept of the plant.

EtherNet/IP

The standard ANSI/TIA/EIA-568-B.2 Annex specifies CAT 5 as the minimum category for a cable used for EtherNet/IP. CAT 5e and CAT 6 are recommended.

For more information on planning and installing EtherNet/IP networks, please refer to the "Media Planning and Installation Manual. EtherNet/IP" of ODVA Organization

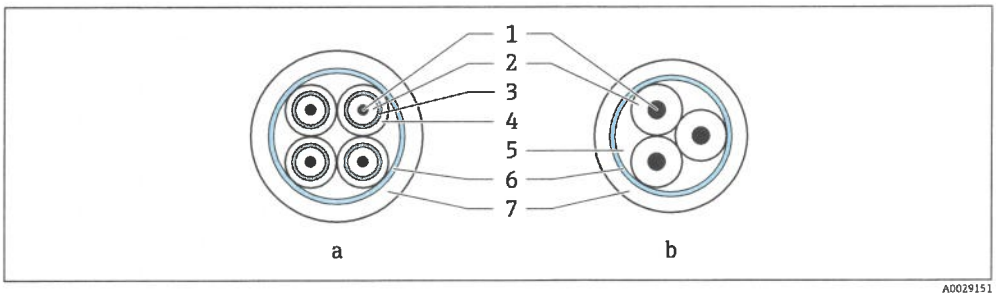
Connecting cable for remote version

Electrode cable

Standard cable	3 ×0.38 mm² (20 AWG) with common, braided copper shield (Φ ~9.5 mm (0.37 in)) and individual shielded cores
Cable for empty pipe detection (EPD)	4 ×0.38 mm² (20 AWG) with common, braided copper shield (Φ ~9.5 mm (0.37 in)) and individual shielded cores
Conductor resistance	≤50 Ω/km (0.015 Ω/ft)
Capacitance: core/shield	≤420 pF/m (128 pF/ft)
Operating temperature	–20 to +80 °C (–4 to +176 °F)

Coil current cable

Standard cable	3 ×0.75 mm² (18 AWG) with common, braided copper shield (Φ ~9 mm (0.35 in))
Conductor resistance	≤37 Ω/km (0.011 Ω/ft)
Capacitance: core/core, shield grounded	≤120 pF/m (37 pF/ft)
Operating temperature	–20 to +80 °C (–4 to +176 °F)
Test voltage for cable insulation	≤ AC 1433 V r.m.s. 50/60 Hz or ≥ DC 2026 V



16 *Cable cross-section*

a *Electrode cable*
b *Coil current cable*
1 *Core*
2 *Core insulation*
3 *Core shield*
4 *Core jacket*
5 *Core reinforcement*
6 *Cable shield*
7 *Outer jacket*

A connecting cable can be ordered from Endress+Hauser for IP68:
- Pre-terminated cables that are already connected to the sensor.
- Pre-terminated cables, where the cables are connected by the customer onsite (incl. tools for sealing the connection compartment)

Reinforced connecting cables

Reinforced connecting cables with an additional, reinforcing metal braid should be used:
- When laying the cable directly in the ground
- Where there is a risk of damage from rodents
- If using the device below IP68 degree of protection

Reinforced connecting cables with an additional, reinforcing metal braid can be ordered from Endress+Hauser .

Operation in areas with strong electrical interference

The measuring system meets the general safety requirements → 93 and EMC specifications → 43.

Grounding is by means of the ground terminal provided for the purpose inside the connection housing. The stripped and twisted lengths of cable shield to the ground terminal must be as short as possible.

Performance characteristics

Reference operating conditions

- Error limits following DIN EN 29104, in future ISO 20456
- Water, typically +15 to +45 °C (+59 to +113 °F); 0.5 to 7 bar (73 to 101 psi)
- Data as indicated in the calibration protocol
- Accuracy based on accredited calibration rigs according to ISO 17025

Maximum measured error

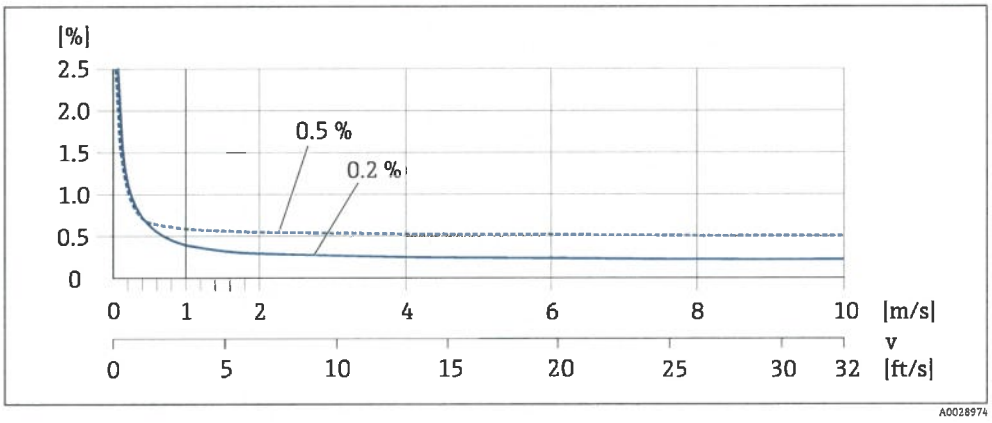
Error limits under reference operating conditions

Volume flow

- ±0.5 % o.r. ± 1 mm/s (0.04 in/s)
- Optional: ±0.2 % o.r. ± 2 mm/s (0.08 in/s)

Order code for "Design"	Installation *with* inlet and outlet runs max. measured error 0.5 %	Installation *with* inlet and outlet runs max. measured error 0.2 %	Installation *without* inlet and outlet runs max. measured error 0.5 %
Options A, B, D, E, F, G (standard)	☑	☑	not recommended
Options C, H, I (0 x DN)	☑	☑	☑

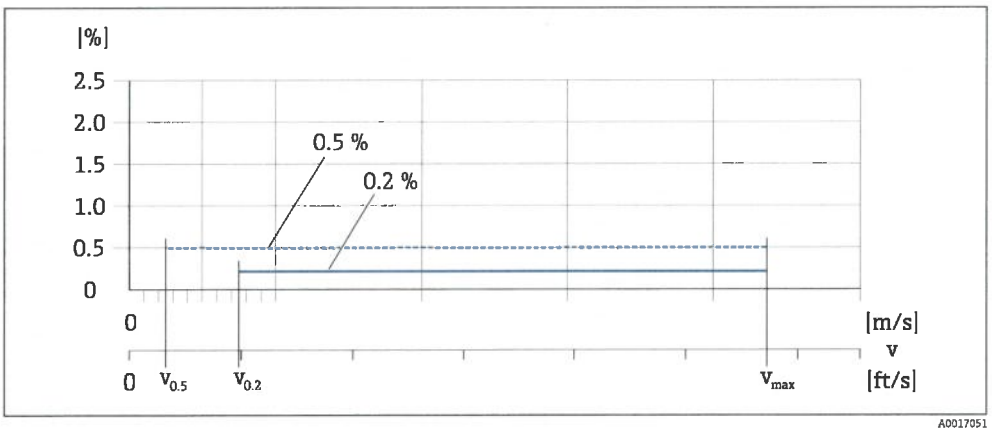
Fluctuations in the supply voltage do not have any effect within the specified range.



17 *Maximum measured error in % o.r.*

Flat Spec

For Flat Spec in the range $v_{0.5}$ ($v_{0.2}$) up to v_{max} the measured error is constant.



18 *Flat Spec in % o.r.*

Flat Spec flow values 0.5 %

Nominal diameter [mm]	Nominal diameter [in]	$v_{0.5}$ [m/s]	$v_{0.5}$ [ft/s]	v_{max} [m/s]	v_{max} [ft/s]
25 to 600	1 to 24	0.5	1.64	10	32
50 to 300 [1)]	2 to 12	0.25	0.82	5	16

1) Order code for "Design", option C

Flat Spec flow values 0.2 %

Nominal diameter		$v_{0.2}$		v_{max}	
[mm]	[in]	[m/s]	[ft/s]	[m/s]	[ft/s]
25 to 600	1 to 24	1.5	4.92	10	32
50 to 300 [1)]	2 to 12	0.6	1.97	4	13

1) Order code for "Design", option C

Electrical conductivity

Max. measured error not specified.

Accuracy of outputs

The outputs have the following base accuracy specifications.

Current output

Accuracy	Max. ±5 µA

Pulse/frequency output

o.r. = of reading

Accuracy	Max. ±50 ppm o.r. (over the entire ambient temperature range)

Repeatability

o.r. = of reading

Volume flow
max. ±0.1 % o.r. ± 0.5 mm/s (0.02 in/s)

Electrical conductivity
Max. ±5 % o.r.

Influence of ambient temperature

Current output

o.r. = of reading

Temperature coefficient	Max. ±0.005 % o.r./°C

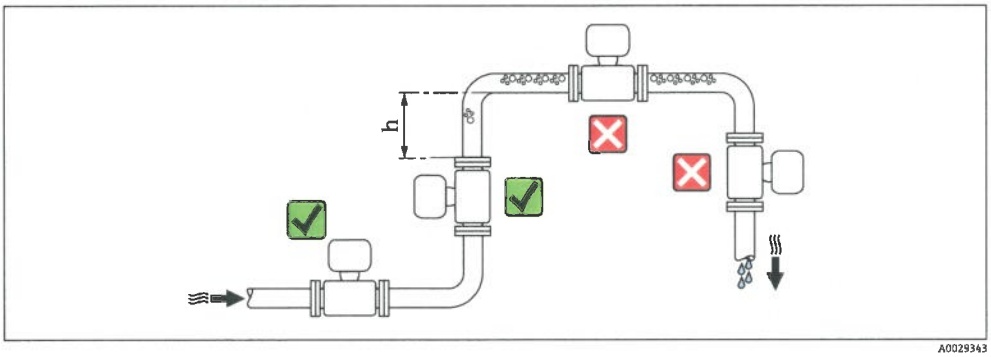
Pulse/frequency output

Temperature coefficient	No additional effect. Included in accuracy.

Installation

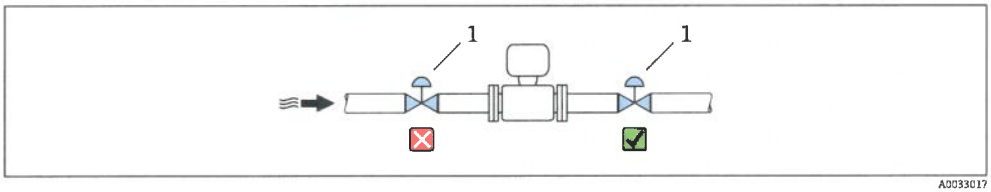
No special measures such as supports etc. are necessary. External forces are absorbed by the construction of the device.

Mounting location



Preferably install the sensor in an ascending pipe, and ensure a sufficient distance to the next pipe elbow: h ≥ 2 × DN.

Distance h ≥ 2 × DN not necessary with order code for "Design", option C, H, I.

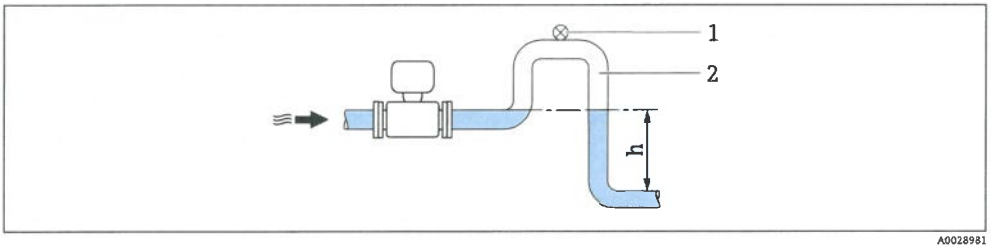


19 *Installation of the sensor after a control valve is not recommended*

1 Control valve

Installation in down pipes

Install a siphon with a vent valve downstream of the sensor in down pipes whose length h ≥ 5 m (16.4 ft). This precaution is to avoid low pressure and the consequent risk of damage to the measuring tube. This measure also prevents the system losing prime.



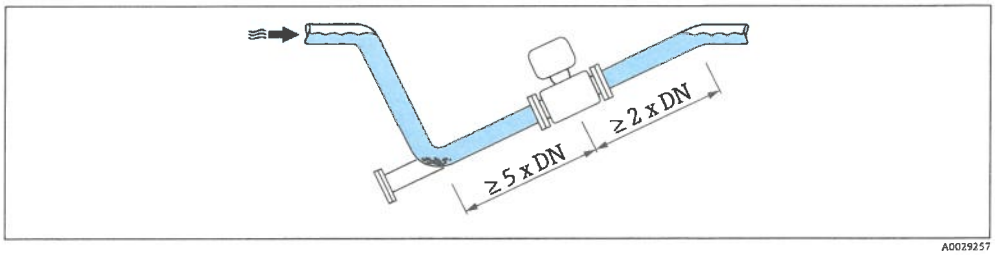
20 *Installation in a down pipe*

1 Vent valve
2 Pipe siphon
h Length of down pipe

Installation in partially filled pipes

A partially filled pipe with a gradient necessitates a drain-type configuration.

No inlet runs necessary with order code for "Design", option C, H, I



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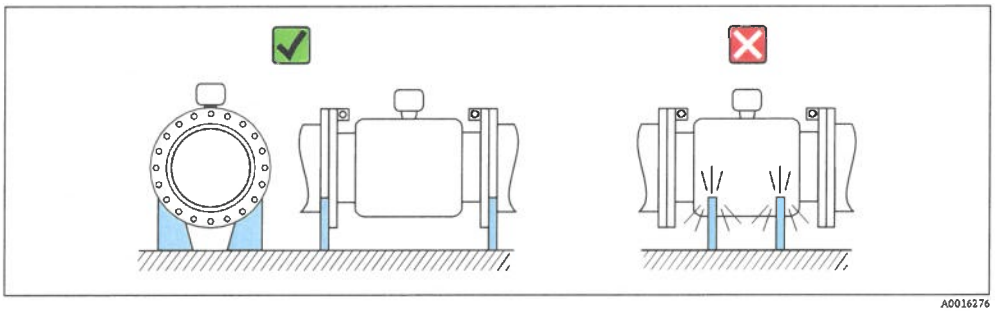
For heavy sensors DN ≥ 350 (14")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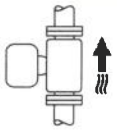
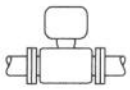
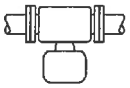
Orientation

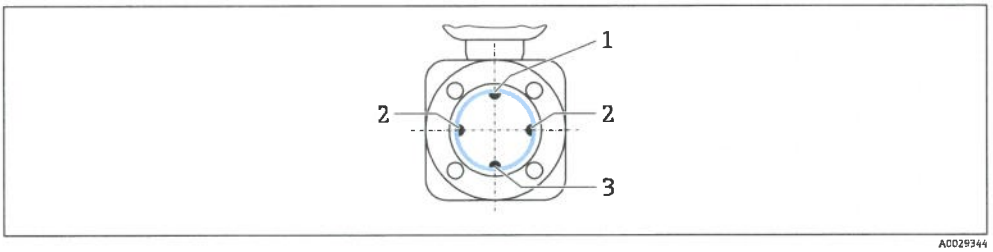
The direction of the arrow on the sensor nameplate helps you to install the sensor according to the flow direction (direction of medium flow through the piping).

	Orientation		Recommendation
A	Vertical orientation	 A0015591	✓✓
B	Horizontal orientation, transmitter at top	 A0015589	✓✓ 1)
C	Horizontal orientation, transmitter at bottom	 A0015590	✓✓ 2) 3) ✗ 4)
D	Horizontal orientation, transmitter at side	 A0015592	✗

1) Applications with low process temperatures may decrease the ambient temperature. To maintain the minimum ambient temperature for the transmitter, this orientation is recommended.
2) Applications with high process temperatures may increase the ambient temperature. To maintain the maximum ambient temperature for the transmitter, this orientation is recommended.
3) To prevent the electronics module from overheating in the case of a sharp rise in temperature (e.g. CIP or SIP processes), install the device with the transmitter component pointing downwards.
4) With the empty pipe detection function switched on: empty pipe detection only works if the transmitter housing is pointing upwards.

Horizontal

- Ideally, the measuring electrode plane should be horizontal. This prevents brief insulation of the measuring electrodes by entrained air bubbles.
- Empty pipe detection only works if the transmitter housing is pointing upwards as otherwise there is no guarantee that the empty pipe detection function will actually respond to a partially filled or empty measuring tube.

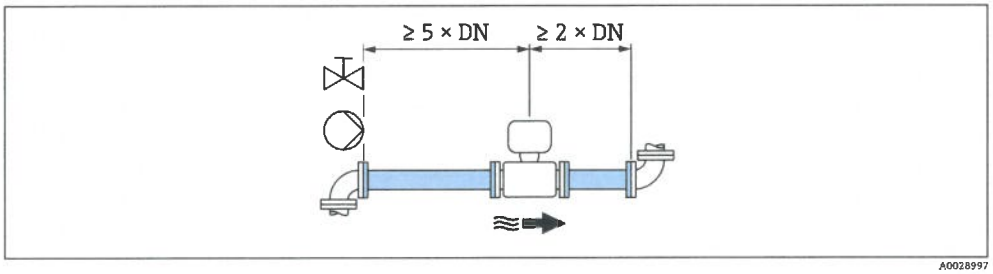


1 EPD electrode for empty pipe detection
2 Measuring electrodes for signal detection
3 Reference electrode for potential equalization

Inlet and outlet runs

If possible, install the sensor upstream from fittings such as valves, T-pieces or elbows.

Observe the following inlet and outlet runs to comply with accuracy specifications:



For sensors with the order code for "Design", option C , H, I , no inlet or outlet runs need to be taken into account.

To keep within the in-service maximum permissible errors for custody transfer no additional requirements apply with regard to the graphic illustrated above.

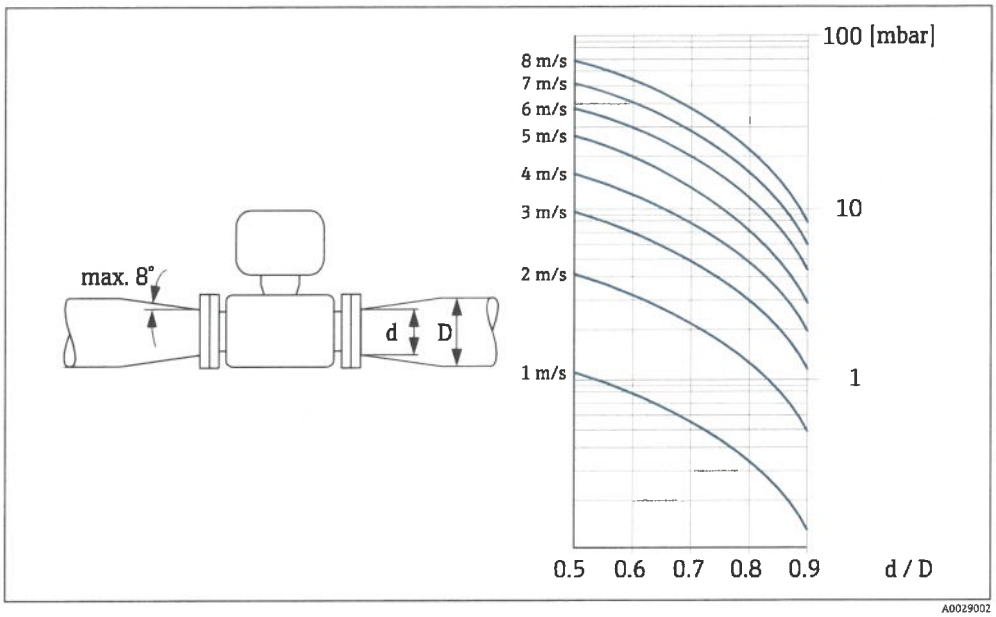
Adapters

Suitable adapters to DIN EN 545 (double-flange reducers) can be used to install the sensor in larger-diameter pipes. The resultant increase in the rate of flow improves measuring accuracy with very slow-moving fluids.

The nomogram shown here can be used to calculate the pressure loss caused by reducers and expanders:

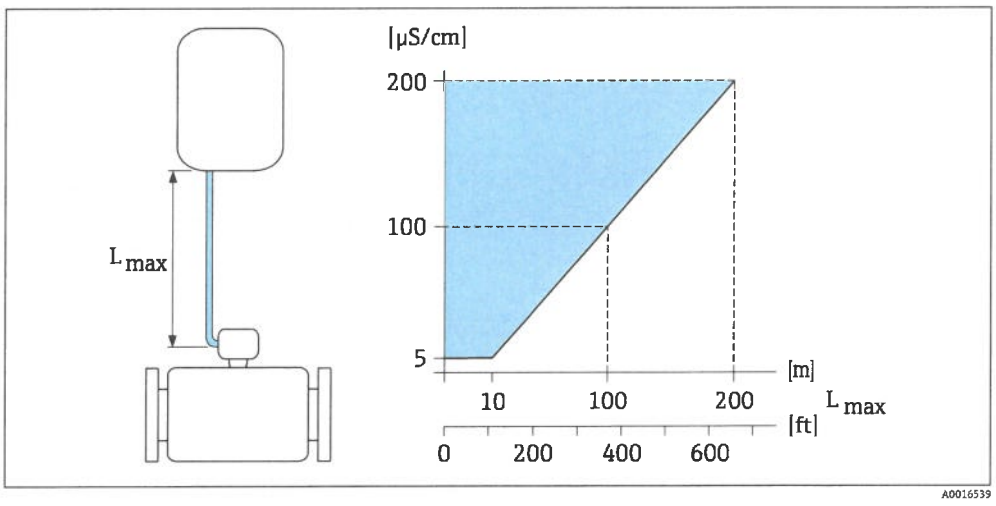
- Calculate the ratio of the diameters d/D.
- From the nomogram read off the pressure loss as a function of flow velocity (downstream from the reduction) and the d/D ratio.

The nomogram only applies to liquids with a viscosity similar to that of water.



Length of connecting cable

To obtain correct measurement results, observe the permitted connecting cable length of L_{max}. This length is determined by the conductivity of the fluid. If measuring liquids in general: 5 µS/cm

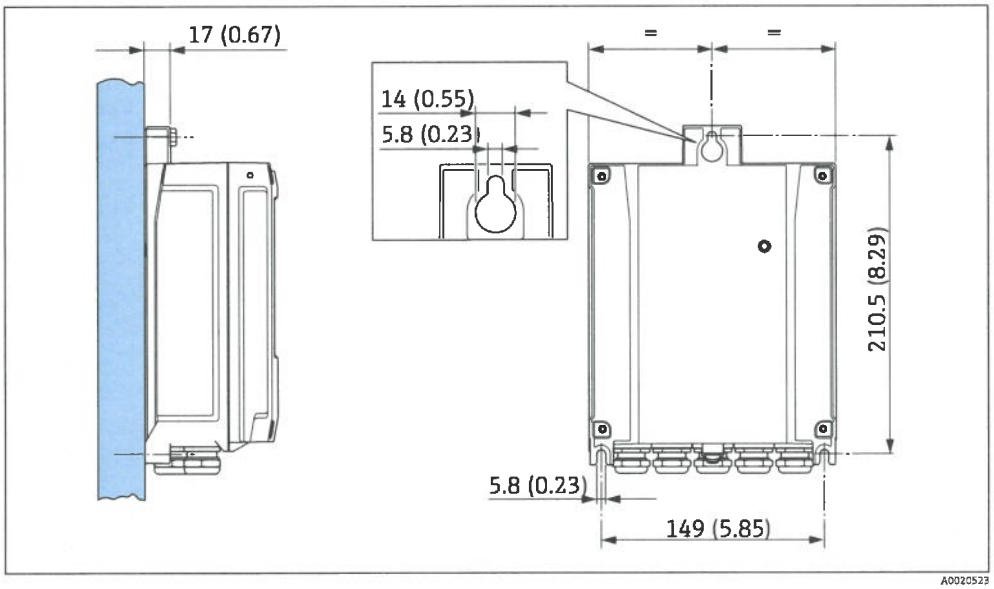


21 *Permitted length of connecting cable*

Colored area = permitted range
L_{max} = length of connecting cable in [m] ([ft])
[µS/cm] = fluid conductivity

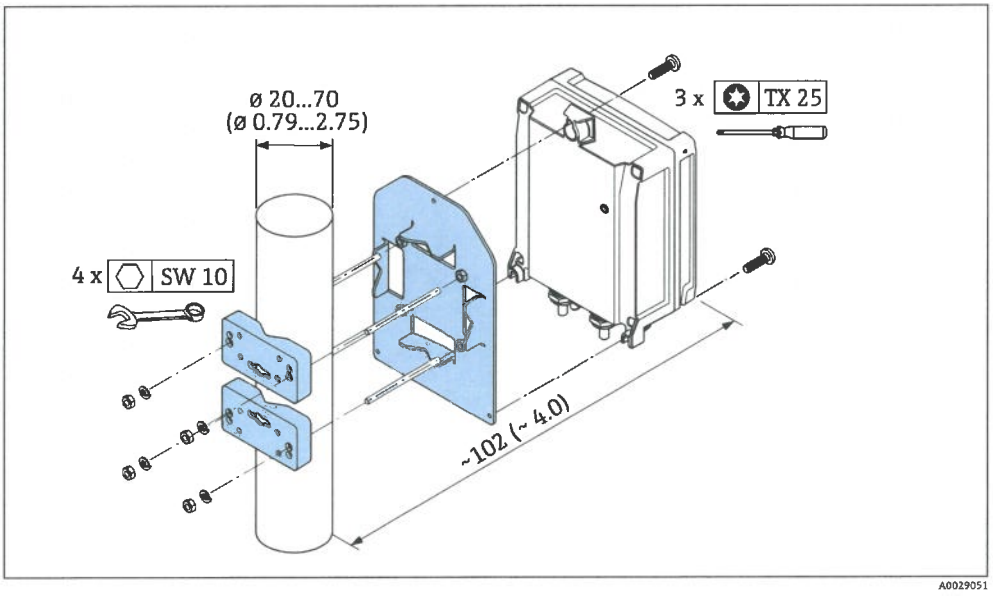
Mounting the transmitter housing

Wall mounting



22 *Engineering unit mm (in)*

Post mounting



23 *Engineering unit mm (in)*

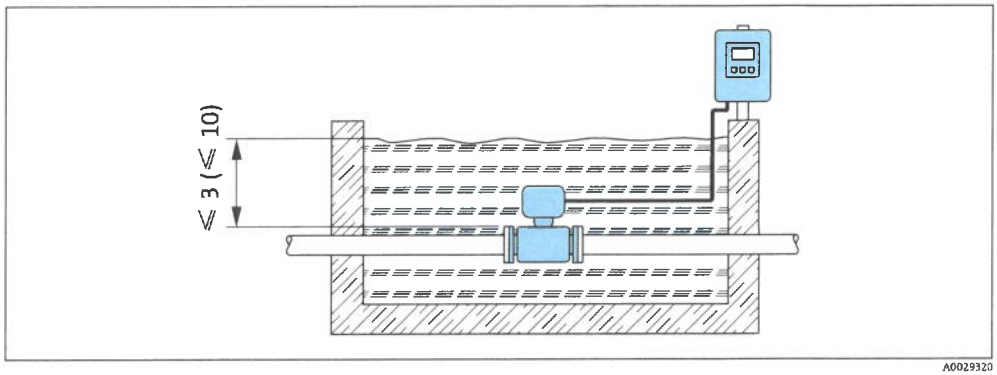
Special mounting instructions

Display guard

To ensure that the optional display guard can be easily opened, maintain the following minimum head clearance: 350 mm (13.8 in)

Permanent immersion in water

A fully welded remote version with IP68 protection is optionally available for permanent immersion in water ≤ 3 m (10 ft) or in exceptional cases for use for up to 48 hours at ≤ 10 m (30 ft). The measuring device meets the requirements of corrosion categories C5-M and Im1/Im2/Im3. The fully welded design along with the connection compartment sealing system ensure that moisture cannot enter the measuring device.

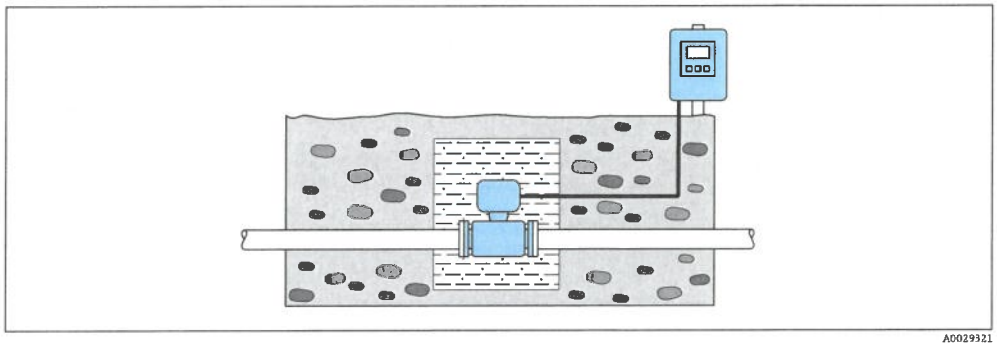


24 *Engineering unit in m(ft)*

Replacement of cable gland on connection housing

Buried applications

A remote version with IP68 protection is optionally available for buried applications. The measuring device satisfies the certified corrosion protection Im1/Im2/Im3 in accordance with EN ISO 12944. It can be used directly underground without the need for additional protective measures. The device is mounted in accordance with the usual regional installation regulations (e.g. EN DIN 1610).



Environment

Ambient temperature range

Transmitter	−40 to +60 °C (−40 to +140 °F)
Local display	−20 to +60 °C (−4 to +140 °F), the readability of the display may be impaired at temperatures outside the temperature range.
Sensor	▪ Process connection material, carbon steel: −10 to +60 °C (+14 to +140 °F) ▪ Process connection material, stainless steel: −40 to +60 °C (−40 to +140 °F) Mount the transmitter separately from the sensor if both the ambient and fluid temperatures are high.
Liner	Do not exceed or fall below the permitted temperature range of the liner .

If operating outdoors:
- Install the measuring device in a shady location.
- Avoid direct sunlight, particularly in warm climatic regions.
- Avoid direct exposure to weather conditions.

- If the compact version of the device is insulated at low temperatures, the insulation must also include the device neck.
- Protect the display against impact.
- Protect the display from abrasion by sand in desert areas.

Display guard available as an accessory → 96.

Temperature tables

Observe the interdependencies between the permitted ambient and fluid temperatures when operating the device in hazardous areas.

For detailed information on the temperature tables, see the separate document entitled "Safety Instructions" (XA) for the device.

Storage temperature

The storage temperature corresponds to the operating temperature range of the transmitter and the sensor → 41.

- Protect the measuring device against direct sunlight during storage in order to avoid unacceptably high surface temperatures.
- Select a storage location where moisture cannot collect in the measuring device as fungus or bacteria infestation can damage the liner.
- If protection caps or protective covers are mounted these should never be removed before installing the measuring device.

Atmosphere

If a plastic transmitter housing is permanently exposed to certain steam and air mixtures, this can damage the housing.

In cases of doubt, please contact the Sales Center.

Degree of protection

Transmitter
- As standard: IP66/67, type 4X enclosure
- When housing is open: IP20, type 1 enclosure

Sensor
- As standard: IP66/67, type 4X enclosure
- Optionally available for compact and remote version:
  IP66/67, type 4X enclosure; fully welded, with protective varnish EN ISO 12944 C5-M. Suitable for use in corrosive atmospheres.
- Optionally available for remote version:
  - IP68, type 6P enclosure; fully welded, with protective varnish as per EN ISO 12944 C5-M. Suitable for permanent immersion in water ≤ 3 m (10 ft) or up to 48 hours at depths ≤ 10 m (30 ft).
  - IP68, type 6P enclosure; fully welded, with protective varnish as per EN ISO 12944 Im1/Im2/Im3. Suitable for permanent immersion in saline water ≤ 3 m (10 ft) or up to 48 hours at depths ≤ 10 m (30 ft) or in buried applications.

Vibration- and shock-resistance

Vibration sinusoidal, in accordance with IEC 60068-2-6

Compact version; order code for "Housing", option A "Compact, alu, coated"
- 2 to 8.4 Hz, 3.5 mm peak
- 8.4 to 2 000 Hz, 1 g peak

Compact version; order code for "Housing", option M "Compact, polycarbonate"
- 2 to 8.4 Hz, 7.5 mm peak
- 8.4 to 2 000 Hz, 2 g peak

Remote version; order code for "Housing", option N "Remote, polycarbonate" and option P "Remote, alu, coated"
- 2 to 8.4 Hz, 7.5 mm peak
- 8.4 to 2 000 Hz, 2 g peak

Vibration broad-band random, according to IEC 60068-2-64

Compact version; order code for "Housing", option A "Compact, alu, coated"
- 10 to 200 Hz, 0.003 g^2/Hz
- 200 to 2 000 Hz, 0.001 g^2/Hz
- Total: 1.54 g rms

Compact version; order code for "Housing", option M "Compact, polycarbonate"
- 10 to 200 Hz, 0.01 g^2/Hz
- 200 to 2 000 Hz, 0.003 g^2/Hz
- Total: 2.70 g rms

Remote version; order code for "Housing", option N "Remote, polycarbonate" and option P "Remote, alu, coated"
- 10 to 200 Hz, 0.01 g^2/Hz
- 200 to 2 000 Hz, 0.003 g^2/Hz
- Total: 2.70 g rms

Shock half-sine, according to IEC 60068-2-27

- Compact version; order code for "Housing", option A "Compact, alu, coated"
  6 ms 30 g
- Compact version; order code for "Housing", option M "Compact, polycarbonate"
  6 ms 50 g
- Remote version; order code for "Housing", option N "Remote, polycarbonate" and option P "Remote, alu, coated"
  6 ms 50 g

Rough handling shocks according to IEC 60068-2-31

Mechanical load

- Protect the transmitter housing against mechanical effects, such as shock or impact; the use of the remote version is sometimes preferable.
- Never use the transmitter housing as a ladder or climbing aid.

Electromagnetic compatibility (EMC)

- As per IEC/EN 61326 and NAMUR Recommendation 21 (NE 21)
- Complies with emission limits for industry as per EN 55011 (Class A)
- Device version with PROFIBUS DP: Complies with emission limits for industry as per EN 50170 Volume 2, IEC 61784

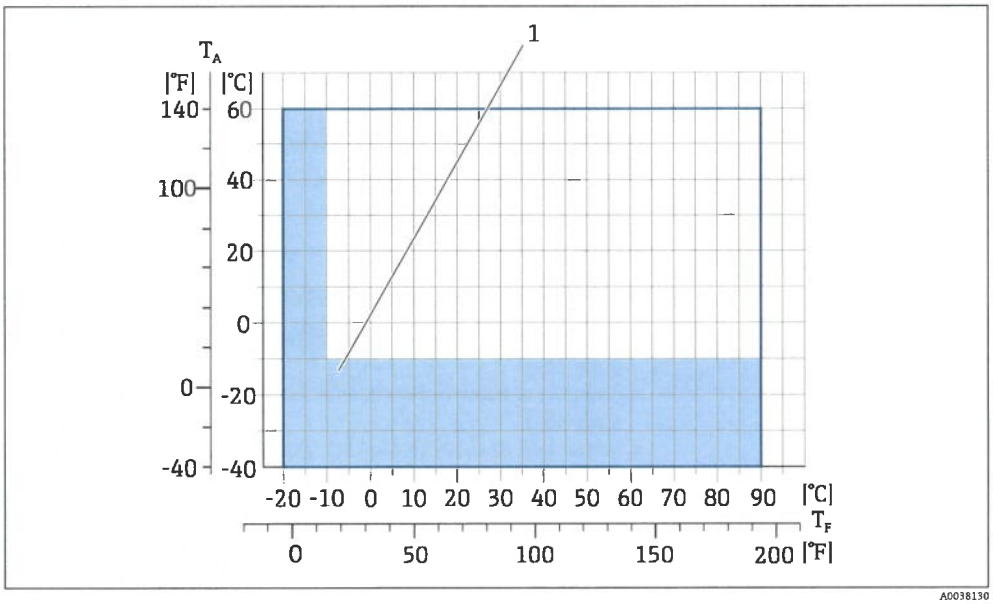
The following applies for PROFIBUS DP: If baud rates > 1.5 MBaud, an EMC cable entry must be used and the cable shield must continue as far as the terminal wherever possible.

Details are provided in the Declaration of Conformity.

Process

Medium temperature range

- 0 to +80 °C (+32 to +176 °F) for hard rubber, DN 50 to 2400 (2 to 90")
- −20 to +50 °C (−4 to +122 °F) for polyurethane, DN 25 to 1200 (1 to 48")
- −20 to +90 °C (−4 to +194 °F) for PTFE, DN 25 to 300 (1 to 12")



T_A *Ambient temperature range*
T_F *Medium temperature*
1 Colored area: the ambient temperature range of −10 to −40 °C (+14 to −40 °F) and the fluid temperature range of −10 to −20 °C (+14 to −4 °F) applies to stainless flanges only

The permitted fluid temperature in custody transfer is 0 to +50 °C (+32 to +122 °F).

Conductivity

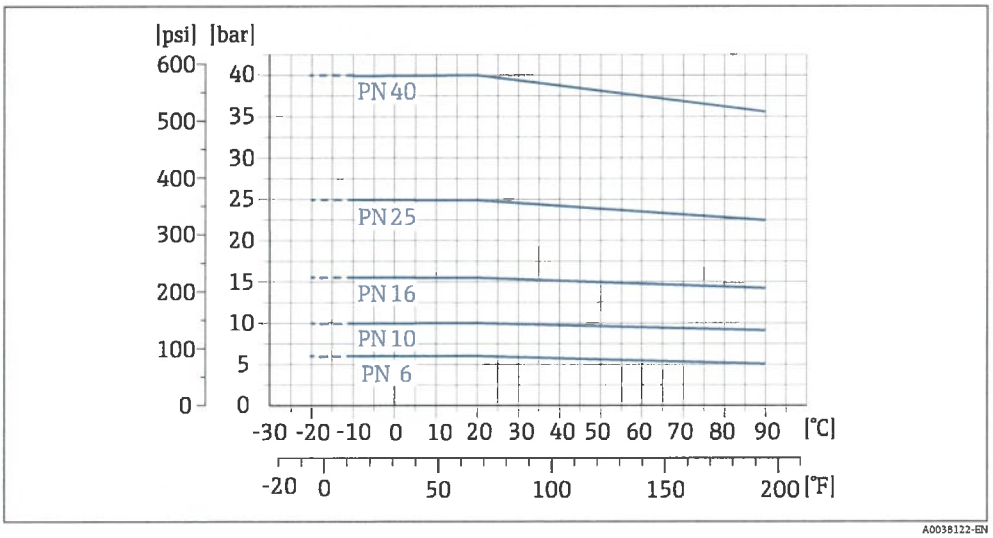
≥ 5 µS/cm for liquids in general.

Remote version
The necessary minimum conductivity also depends on the cable length → 39.

Pressure-temperature ratings

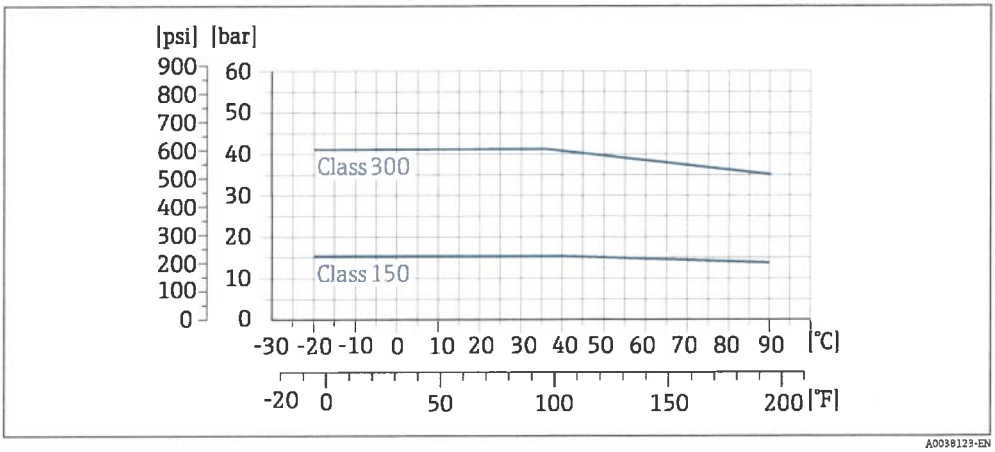
The following pressure/temperature diagrams apply to all pressure-bearing parts of the device and not just the process connection. The diagrams show the maximum permissible medium pressure depending on the specific medium temperature.

Process connection: fixed flange according to EN 1092-1 (DIN 2501)

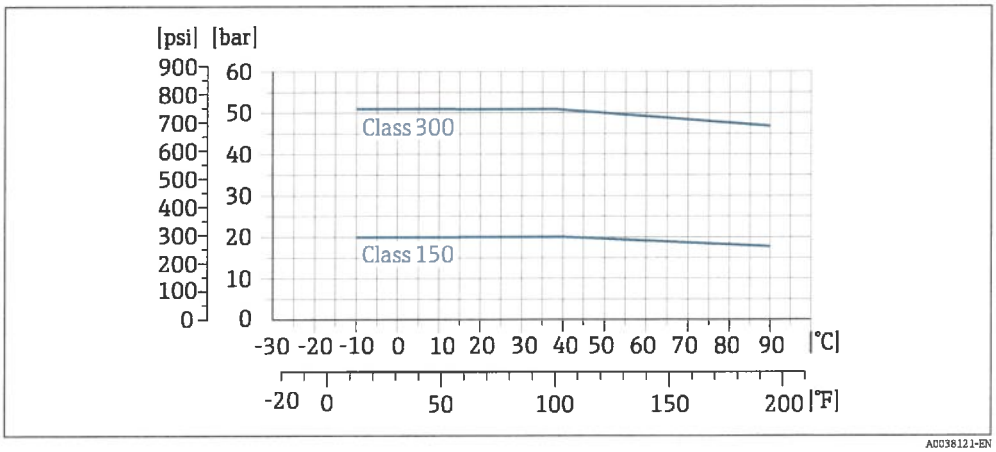


25 *Process connection material: stainless steel (−20 °C (−4 °F)); carbon steel (−10 °C (14 °F))*

Process connection: fixed flange according to ASME B16.5

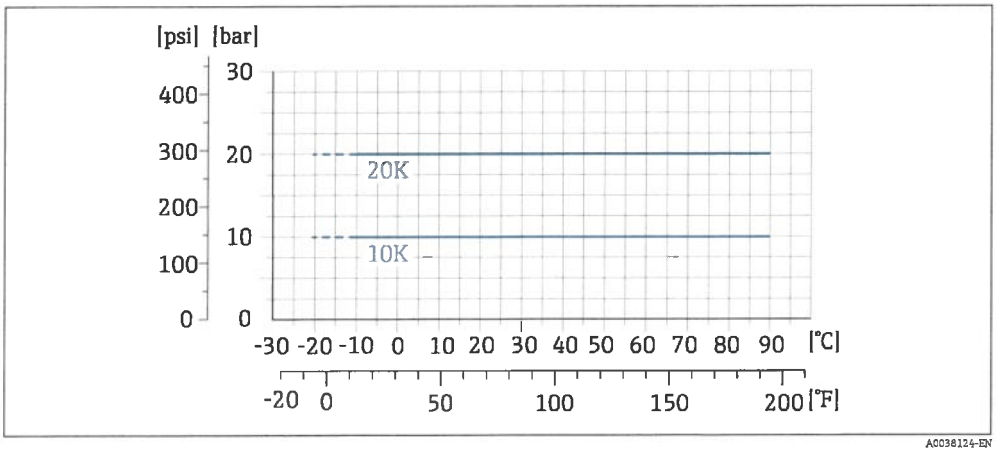


26 *Process connection material: stainless steel*



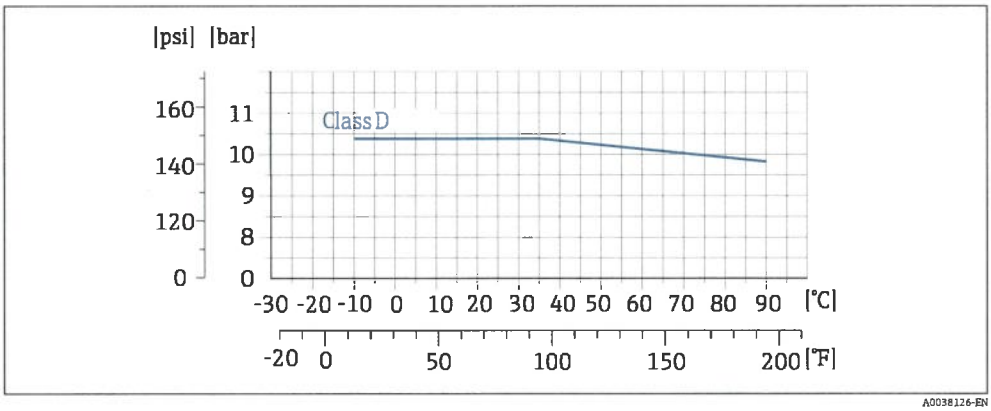
27 *Process connection material: carbon steel*

Process connection: fixed flange according to JIS B2220



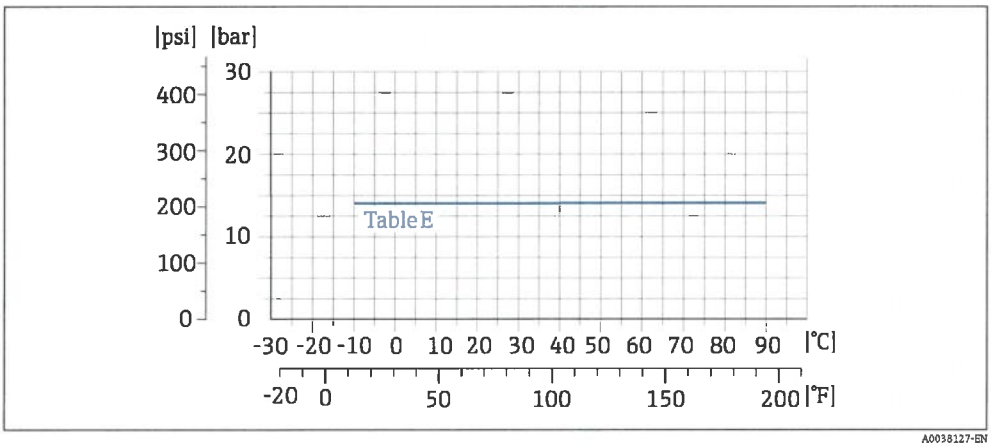
28 *Process connection material: stainless steel (−20 °C (−4 °F)); carbon steel (−10 °C (14 °F))*

Process connection: fixed flange according to AWWA C207



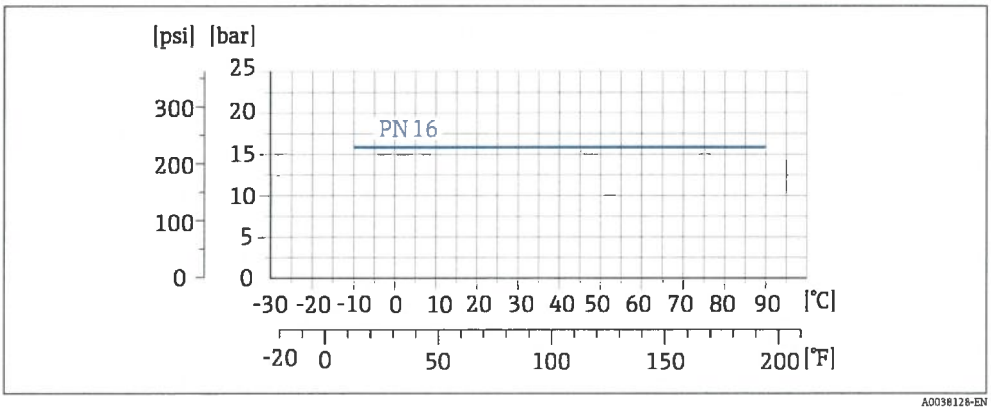
29 *Process connection material: carbon steel*

Process connection: fixed flange according to AS 2129



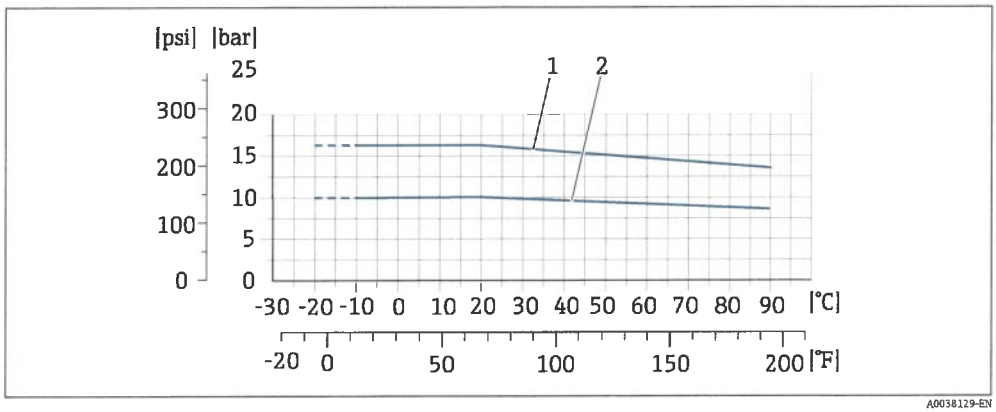
30 *Process connection material: carbon steel*

Process connection: fixed flange according to AS 4087



31 *Process connection material: carbon steel*

Process connection: lap joint flange/lap joint flange, stamped plate according to EN 1092-1 (DIN 2501) and ASME B16.5; DN 25 to 300 (1 to 12")



32 *Process connection material: stainless steel (-20 °C (-4 °F)); carbon steel (-10 °C (14 °F))*

1 *Lap joint flange PN16/ Class150*
2 *Lap joint flange, stamped plate PN10, lap joint flange PN10*

Pressure tightness

Liner: hard rubber

Nominal diameter		Limit values for absolute pressure in [mbar] ([psi]) for medium temperatures:		
[mm]	[in]	+25 °C (+77 °F)	+50 °C (+122 °F)	+80 °C (+176 °F)
50 ... 2400	2 ... 90	0 (0)	0 (0)	0 (0)

Liner: polyurethane

Nominal diameter		Limit values for absolute pressure in [mbar] ([psi]) for medium temperatures:	
[mm]	[in]	+25 °C (+77 °F)	+50 °C (+122 °F)
25 ... 1200	1 ... 48	0 (0)	0 (0)

Liner: PTFE

Nominal diameter		Limit values for absolute pressure in [mbar] ([psi]) for medium temperatures:	
[mm]	[in]	+25 °C (+77 °F)	+90 °C (+194 °F)
25	1	0 (0)	0 (0)
40	2	0 (0)	0 (0)
50	2	0 (0)	0 (0)
65	2 ½	0 (0)	40 (0.58)
80	3	0 (0)	40 (0.58)
100	4	0 (0)	135 (2.0)
125	5	135 (2.0)	240 (3.5)
150	6	135 (2.0)	240 (3.5)
200	8	200 (2.9)	290 (4.2)
250	10	330 (4.8)	400 (5.8)
300	12	400 (5.8)	500 (7.3)

Flow limit

The diameter of the pipe and the flow rate determine the nominal diameter of the sensor. The optimum velocity of flow is between 2 to 3 m/s (6.56 to 9.84 ft/s). Also match the velocity of flow (v) to the physical properties of the fluid:

- v < 2 m/s (6.56 ft/s): for abrasive fluids (e.g. potter's clay, lime milk, ore slurry)
- v > 2 m/s (6.56 ft/s): for fluids producing buildup (e.g. wastewater sludge)

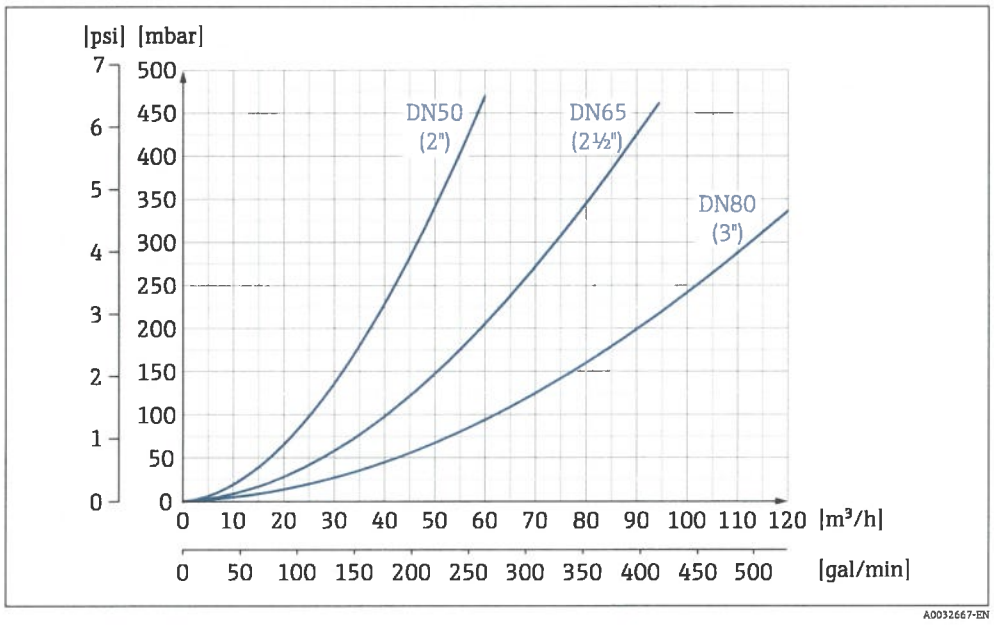
A necessary increase in the flow velocity can be achieved by reducing the sensor nominal diameter.

For an overview of the full scale values for the measuring range, see the "Measuring range" section → 9

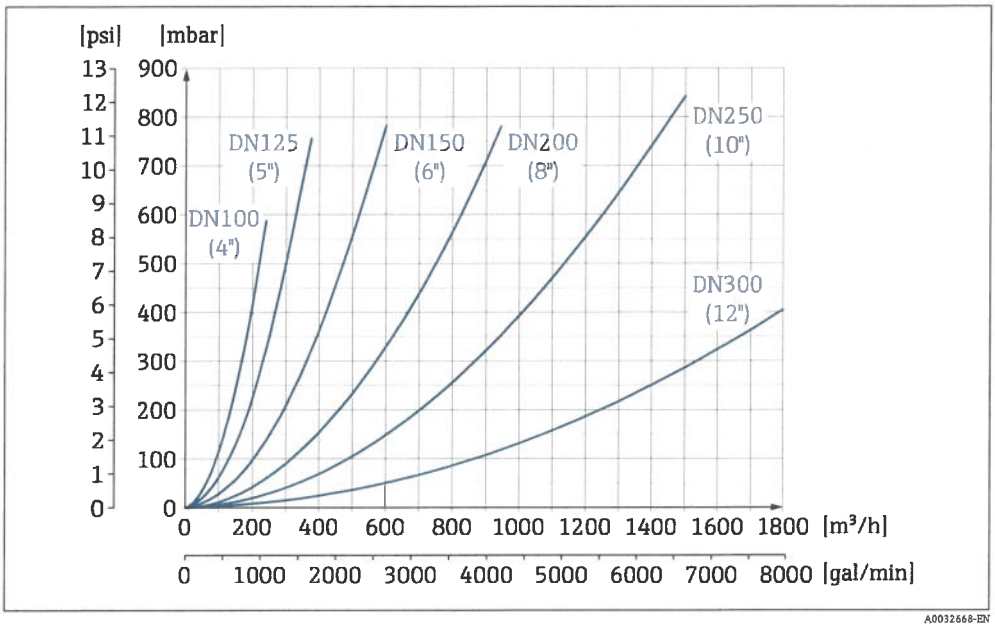
For custody transfer, the applicable approval determines the permitted measuring range.

Pressure loss

- No pressure loss occurs if the sensor is installed in a pipe with the same nominal diameter.
- Pressure losses for configurations incorporating adapters according to DIN EN 545 → 38

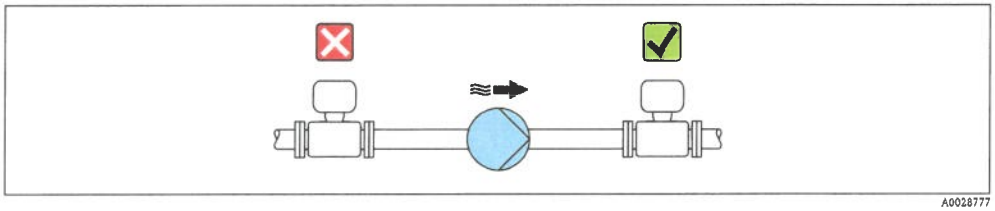


33 *Pressure loss DN 50 to 80 (2 to 3") for order code for "Design", option C "fixed flange, without inlet/outlet runs"*



34 *Pressure loss DN 100 to 300 (4 to 12") for order code for "Design", option C "fixed flange, without inlet/ outlet runs"*

System pressure

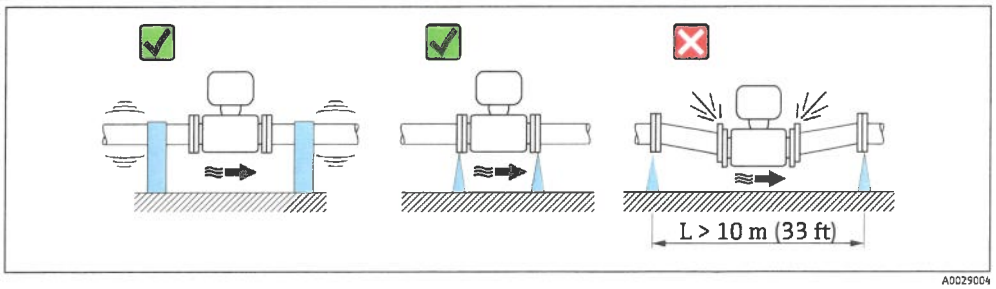


Never install the sensor on the pump suction side in order to avoid the risk of low pressure, and thus damage to the liner.

Furthermore, install pulse dampers if reciprocating, diaphragm or peristaltic pumps are used.

- Information on the liner's resistance to partial vacuum → 47
- Information on the shock resistance of the measuring system
- Information on the vibration resistance of the measuring system

Vibrations



35 *Measures to prevent vibration of the device*

In the event of very strong vibrations, the pipe and sensor must be supported and fixed.

It is also advisable to mount the sensor and transmitter separately.

- Information on the shock resistance of the measuring system
- Information on the vibration resistance of the measuring system

Custody transfer mode

The measuring device is optionally tested in accordance with OIML R137 and has an EU type-examination certificate according to Measuring Instruments Directive 2014/32/EU for service subject to legal metrological control ("custody transfer") for cold water (Annex III).

The permitted fluid temperature in these applications is 0 to +50 °C (+32 to +122 °F).

The device is used with a legally controlled totalizer on the local display and optionally with legally controlled outputs.

Measuring devices subject to legal metrological control totalize in both directions, i.e. all the outputs consider flow components in the positive (forward) and negative (reverse) flow direction.

Generally a measuring device subject to legal metrological control is secured against tampering by seals on the transmitter or sensor. These seals may normally only be opened by a representative of the competent authority for legal metrology controls.

After putting the device into circulation or after sealing the device, operation is only possible to a limited extent.

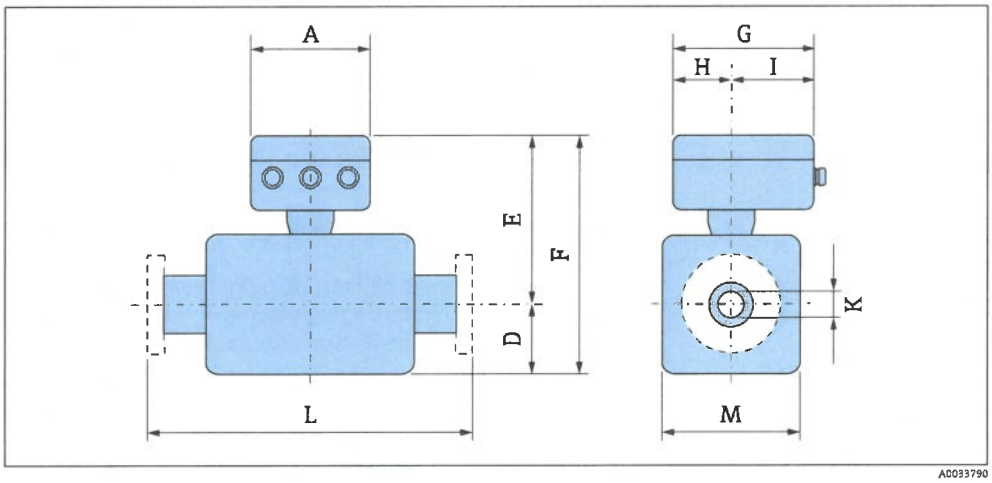
Detailed ordering information is available from your local Endress+Hauser sales center for national approvals (outside Europe) as cold water meters based on OIML R49.

Mechanical construction

Dimensions in SI units

Compact version

Order code for "Housing", option A "Compact, aluminum, coated" or option M "Compact, polycarbonate"



A [mm]	G[1] [mm]	H [mm]	I[1] [mm]
167	193	90	103

1) Depending on the cable gland used: values up to + 30 mm

DN 25 to 300 (1 to 12"): sensor with aluminum half-shell housing

DN		Order code for "Design"								K	L
		Options A, D, E, H, I				Option C					
		D [1]	E [1) 2)]	F [1) 2)]	M [1)]	D [1)]	E [1) 2)]	F [1) 2)]	M [1)]		
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
25	1	84	201	285	120	–	–	–	–	3)	200
32	–	84	201	285	120	–	–	–	–	3)	200
40	1 ½	84	201	285	120	–	–	–	–	3)	200
50	2	84	201	285	120	84	201	285	120	3)	200
65	–	109	226	335	180	84	201	285	120	3)	200
80	3	109	226	335	180	84	201	285	120	3)	200
100	4	109	226	335	180	109	226	335	180	3)	250
125	–	150	266	416	260	109	226	335	180	3)	250
150	6	150	266	416	260	109	226	335	180	3)	300
200	8	180	291	471	324	150	266	416	260	3)	350
250	10	205	316	521	400	150	266	416	260	3)	450
300	12	230	341	571	460	180	291	471	324	3)	500

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) With order code for "Sensor option", option CG "Sensor extended neck for insulation": values + 110 mm
3) Depends on the liner→ 🖹 81

DN 350 to 900 (14 to 36")

DN		Order code for "Design"								K	L	
		Options A, E, F				Option B, G						
		D [1)]	E [1) 2)]	F [1) 2)]	M [1)]	D [1)]	E [1) 2)]	F [1) 2)]	M [1)]			
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	
350	14	245	412	658	490	–	–	–	–	3)	550	
375	15	271	438	709	542	–	–	–	–	3)	550	
400	16	271	438	709	542	–	–	–	–	3)	600	
450	18	299	466	765	598	333	450	783	666	3)	600 [4)]	650 [5)]
500	20	324	491	815	648	359	475	834	717	3)	600 [4)]	650 [5)]
600	24	365	542	907	730	411	528	939	821	3)	600 [4)]	780 [5)]
700	28	430	603	1033	860	512	630	1142	1024	3)	700 [4)]	910 [5)]
750	30	467	641	1108	934	512	630	1142	1024	3)	700 [4)]	910 [5)]
800	32	486	660	1146	972	534	650	1184	1065	3)	800 [4)]	1040 [5)]
900	36	536	710	1246	1072	610	727	1337	1218	3)	900 [4)]	1170 [5)]

1) The dimensions are reference values. They may be different than indicated, depending on the pressure rating, design and order code.
2) With order code for "Sensor option", option CG "Sensor extended neck for insulation": values + 110 mm
3) Depends on the liner→ 🖹 81
4) Order code for "Design", option F "Fixed flange, short installation length"
5) Order code for "Design", option G "Fixed flange, long installation length"

DN 1000 to 2400 (40 to 90")

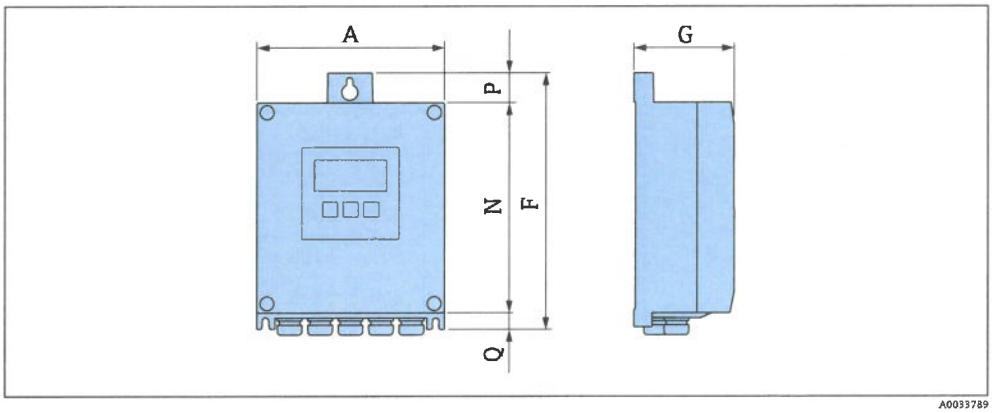
DN		D [1]	E [1) 2)]	F [1) 2)]	K	L		M [1]
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]		[mm]
1000	40	686	803	1489	[3]	1000 [4]	1300 [5]	1370
–	42	712	828	1540	[3]	1050 [4]	1365 [5]	1420
1200	48	811	929	1740	[3]	1200 [4]	1560 [5]	1620
–	54	912	1029	1941	[3]	1350 [4]	1755 [5]	1820
1400	–	987	1104	2091	[3]	1400 [4]	1820 [5]	1970
–	60	1011	1128	2139	[3]	1500 [4]	1950 [5]	2018
1600	–	1056	1173	2229	[3]	1600 [4]	2080 [5]	2108
–	66	1093	1209	2302	[3]	1650 [4]	2145 [5]	2180
1800	72	1188	1304	2492	[3]	1800 [4]	2340 [5]	2370
–	78	1238	1354	2592	[3]	2000 [4]	2600 [5]	2470
2000	–	1238	1354	2592	[3]	2000 [4]	2600 [5]	2470
–	84	1238	1354	2592	[3]	2200 [4]		2470
2200	–	1227	1346	2573	[3]	2200 [4]		2454
–	90	1227	1346	2573	[3]	2400 [4]		2454
2400	–	1332	1451	2783	[3]	2400 [4]		2664

1) The dimensions are reference values. They may be different than indicated, depending on the pressure rating, design and order code.
2) With order code for "Sensor option", option CG "Sensor extended neck for insulation": values + 110 mm
3) Depends on the liner→ 81
4) Order code for "Design", option F "Fixed flange, short installation length"
5) Order code for "Design", option G "Fixed flange, long installation length"

Remote version

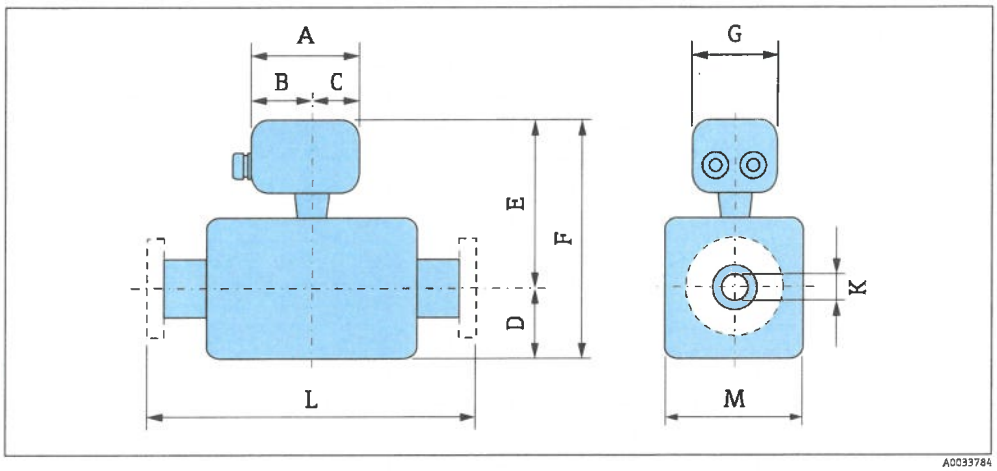
Transmitter remote version

Order code for "Housing", option N "Remote, polycarbonate" or option P "Remote, aluminum coated"



A [mm]	F [mm]	G [mm]	N [mm]	P [mm]	Q [mm]
167	232	80	187	24	21

Sensor connection housing



Aluminum, coated

A [mm]	B [mm]	C [mm]	G [mm]
148	94	54	136

Polycarbonate (only in conjunction with order code for "Sensor option", options CA...CE)

A [mm]	B [mm]	C [mm]	G [mm]
113	62	51	112

DN 25 to 300 (1 to 12"): sensor with aluminum half-shell housing

DN		Order code for "Design"								K	L
		Options A, D, E, H, I				Option C					
		D [1]	E [1]	F [1]	M [1]	D [1]	E [1]	F [1]	M [1]		
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
25	1	84	200	284	120	–	–	–	–	[2]	200
32	–	84	200	284	120	–	–	–	–	[2]	200
40	1 ½	84	200	284	120	–	–	–	–	[2]	200
50	2	84	200	284	120	84	200	284	120	[2]	200
65	–	109	225	334	180	84	200	284	120	[2]	200
80	3	109	225	334	180	84	200	284	120	[2]	200
100	4	109	225	334	180	109	225	334	180	[2]	250
125	–	150	265	415	260	109	225	334	180	[2]	250
150	6	150	265	415	260	109	225	334	180	[2]	300
200	8	180	290	470	324	150	265	415	260	[2]	350
250	10	205	315	520	400	150	265	415	260	[2]	450
300	12	230	340	570	460	180	290	470	324	[2]	500

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) Depends on the liner→ 🖹 81

DN 25 to 300 (1 to 12"): sensor with fully welded carbon steel housing

DN		Order code for "Design"								K	L
		Options A, E				Option C					
		D [1]	E [1]	F [1]	M [1]	D [1]	E [1]	F [1]	M [1]		
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
25	1	70	200	270	140	–	–	–	–	[2]	200
32	–	70	200	270	140	–	–	–	–	[2]	200
40	1 ½	70	200	270	140	–	–	–	–	[2]	200
50	2	70	200	270	140	70	200	270	140	[2]	200
65	–	82	225	307	165	70	200	270	140	[2]	200
80	3	87	225	312	175	70	200	270	140	[2]	200
100	4	100	225	325	200	82	225	307	165	[2]	250
125	–	113	265	378	226	87	225	312	175	[2]	250
150	6	134	265	399	269	100	225	325	200	[2]	300
200	8	160	290	450	320	113	265	378	226	[2]	350
250	10	193	315	508	387	134	265	399	269	[2]	450
300	12	218	340	558	437	160	290	450	320	[2]	500

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) Depends on the liner→ 🖹 81

DN 350 to 900 (14 to 36")

DN		Order code for "Design"								K	L	
		Options A, E, F				Option B, G						
		D [1]	E [1]	F [1]	M [1]	D [1]	E [1]	F [1]	M [1]			
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	
350	14	245	350	595	490	–	–	–	–	[2]	550	
375	15	271	375	646	542	–	–	–	–	[2]	550	
400	16	271	375	646	542	–	–	–	–	[2]	600	
450	18	299	403	702	598	333	447	780	666	[2]	600 [3]	650 [4]
500	20	324	428	752	648	359	472	831	717	[2]	600 [3]	650 [4]
600	24	365	479	844	730	411	525	936	821	[2]	600 [3]	780 [4]
700	28	430	540	970	860	512	627	1139	1024	[2]	700 [3]	910 [4]
750	30	467	578	1045	934	512	627	1139	1024	[2]	700 [3]	910 [4]
800	32	486	597	1083	972	534	647	1181	1065	[2]	800 [3]	1040 [4]
900	36	536	647	1183	1072	610	724	1334	1218	[2]	900 [3]	1170 [4]

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) Depends on the liner→ 🖹 81
3) Order code for "Design", option F "Fixed flange, short installation length"
4) Order code for "Design", option G "Fixed flange, long installation length"

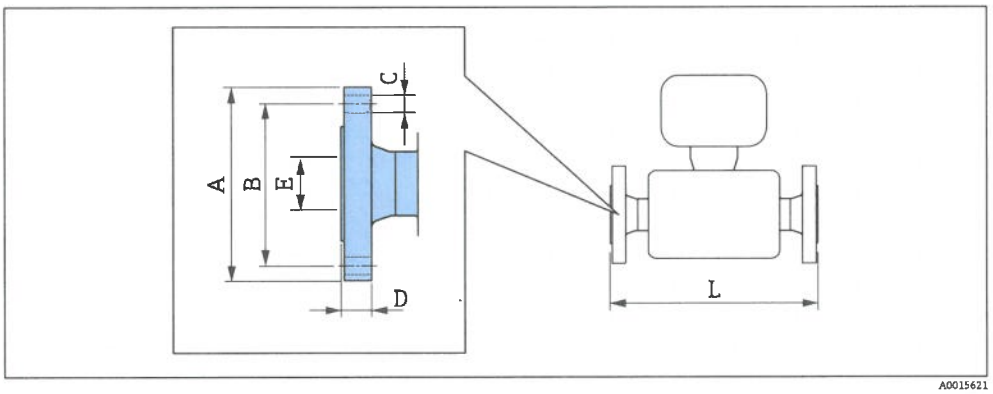
1000 ... 2400 (40 ... 90")

DN		D [1]	E [1]	F [1]	K	L		M [1]
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]		[mm]
1000	40	686	800	1486	[2]	1000 [3]	1300 [4]	1370
–	42	712	825	1537	[2]	1050 [3]	1365 [4]	1420
1200	48	811	926	1737	[2]	1200 [3]	1560 [4]	1620
–	54	912	1026	1938	[2]	1350 [3]	1755 [4]	1820
1400	–	987	1101	2088	[2]	1400 [3]	1820 [4]	1970
–	60	1011	1125	2136	[2]	1500 [3]	1950 [4]	2018
1600	–	1056	1170	2226	[2]	1600 [3]	2080 [4]	2108
–	66	1093	1206	2299	[2]	1650 [3]	2145 [4]	2180
1800	72	1188	1301	2489	[2]	1800 [3]	2340 [4]	2370
–	78	1238	1351	2589	[2]	2000 [3]	2600 [4]	2470
2000	–	1238	1351	2589	[2]	2000 [3]	2600 [4]	2470
–	84	1238	1351	2589	[2]	2200 [3]		2470
2200	–	1227	1343	2570	[2]	2200 [3]		2454
–	90	1227	1343	2570	[2]	2400 [3]		2454
2400	–	1332	1448	2780	[2]	2400 [3]		2664

1) The dimensions are reference values. They may be different than indicated, depending on the pressure rating, design and order code.
2) Internal diameter depends on liner, see measuring tube specification → 🖹 81
3) Order code for "Design", option F "Fixed flange, short installation length"
4) Order code for "Design", option G "Fixed flange, long installation length"

Flange connections

Fixed flange



Flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 6 **Carbon steel:** *order code for "Process connection", option* **D1K** **Stainless steel:** *order code for "Process connection", option* **D1S**						
DN [mm]	**A** [mm]	**B** [mm]	**C** [mm]	**D** [mm]	**E** [mm]	**L** [mm]
350	490	445	12 × Ø22	22	1)	2)
400	540	495	16 × Ø22	22		
450	595	565	20 × Ø26	26		
500	645	600	20 × Ø22	24		
600	755	705	20 × Ø26	30		
700	860	810	24 × Ø26	30		
800	975	920	24 × Ø30	30		
900	1075	1020	24 × Ø30	34		
1000	1175	1120	28 × Ø30	38		
1200	1405	1340	32 × Ø33	42		
1400	1630	1560	36 × Ø36	56		
1600	1830	1760	40 × Ø36	63		
1800	2045	1970	44 × Ø39	69		
2000	2265	2180	48 × Ø42	74		
2200	2475	2390	52 × Ø42	81		
2400	2685	2600	56 × Ø42	87		
Surface roughness (flange): EN 1092-1 Form B1 (DIN 2526 Form C), Ra 6.3 to 12.5 µm						

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 10
Carbon steel: *order code for "Process connection", option* **D2K**
Stainless steel: *order code for "Process connection", option* **D2S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
200	340	295	8 × Ø22	26	1)	2)
250	395	350	12 × Ø22	28		
300	445	400	12 × Ø22	28		
350	505	460	16 × Ø22	26		
400	565	515	16 × Ø26	26		
450	615	565	20 × Ø26	26		
500	670	620	20 × Ø26	28		
600	780	725	20 × Ø30	30		
700	895	840	24 × Ø30	35		
800	1015	950	24 × Ø33	38		
900	1115	1050	28 × Ø33	38		
1000	1230	1160	28 × Ø36	44		
1200	1455	1380	32 × Ø39	55		
1400	1675	1590	36 × Ø42	65		
1600	1915	1820	40 × Ø48	75		
1800	2115	2020	44 × Ø48	85		
2000	2325	2230	48 × Ø48	90		
2200	2550	2440	52 × Ø56	100		
2400	2760	2650	56 × Ø56	110		

Surface roughness (flange): EN 1092-1 Form B1 (DIN 2526 Form C), Ra 6.3 to 12.5 µm

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 16
Carbon steel: *order code for "Process connection", option* **D3K**
Stainless steel: *order code for "Process connection", option* **D3S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
65	185	145	8 × Ø18	20	1)	2)
80	200	160	8 × Ø18	20		
100	220	180	8 × Ø18	22		
125	250	210	8 × Ø18	24		
150	285	240	8 × Ø22	24		
200	340	295	12 × Ø22	26		
250	405	355	12 × Ø26	32		
300	460	410	12 × Ø26	32		
350	520	470	16 × Ø26	30		
400	580	525	16 × Ø30	32		
450	640	585	20 × Ø30	34		
500	715	650	20 × Ø33	36		

Flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 16
Carbon steel: *order code for "Process connection", option* **D3K**
Stainless steel: *order code for "Process connection", option* **D3S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
600	840	770	20 × Ø36	40		
700	910	840	24 × Ø36	40		
800	1025	950	24 × Ø39	41		
900	1125	1050	28 × Ø39	48		
1000	1255	1170	28 × Ø42	59		
1200	1485	1390	32 × Ø48	78		
1400	1685	1590	36 × Ø48	84		
1600	1930	1820	40 × Ø56	102		
1800	2130	2020	44 × Ø56	110		
2000	2345	2230	48 × Ø62	124		

Surface roughness (flange): EN 1092-1 Form B1 (DIN 2526 Form C), Ra 6.3 to 12.5 µm

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 25
Carbon steel: *order code for "Process connection", option* **D4K**
Stainless steel: *order code for "Process connection", option* **D4S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
200	360	310	12 × Ø26	32	1)	2)
250	425	370	12 × Ø30	36		
300	485	430	16 × Ø30	40		
350	555	490	16 × Ø33	38		
400	620	550	16 × Ø36	40		
450	670	600	20 × Ø36	46		
500	730	660	20 × Ø36	48		
600	845	770	20 × Ø39	48		
700	960	875	24 × Ø42	50		
800	1085	990	24 × Ø48	53		
900	1185	1090	28 × Ø48	57		
1000	1320	1210	28 × Ø56	63		

Surface roughness (flange): EN 1092-1 Form B1 (DIN 2526 Form C), Ra 6.3 to 12.5 µm

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 40
Carbon steel: *order code for "Process connection", option* **D5K**
Stainless steel: *order code for "Process connection", option* **D5S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
25	115	85	4 × Ø14	16	1)	2)
32	140	100	4 × Ø18	18		
40	150	110	4 × Ø18	18		
50	165	125	4 × Ø18	20		
65	185	145	8 × Ø18	24		
80	200	160	8 × Ø18	26		
100	235	190	8 × Ø22	26		
125	270	220	8 × Ø26	28		
150	300	250	8 × Ø26	30		

Surface roughness (flange): EN 1092-1 Form B1 (DIN 2526 Form C), Ra 6.3 to 12.5 µm

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange according to ASME B16.5, Class 150
Carbon steel: *order code for "Process connection", option* **A1K**
Stainless steel: *order code for "Process connection", option* **A1S**

DN		A	B	C	D	E	L
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
25	1	108	79.2	4 × Ø16	12.6	1)	2)
40	1 ½	127	98.6	4 × Ø16	15.9		
50	2	152.4	120.7	4 × Ø19.1	17.5		
80	3	190.5	152.4	4 × Ø19.1	22.3		
100	4	228.6	190.5	8 × Ø19.1	22.3		
150	6	279.4	241.3	8 × Ø22.4	23.8		
200	8	342.9	298.5	8 × Ø22.4	26.8		
250	10	406.4	362	12 × Ø25.4	29.6		
300	12	482.6	431.8	12 × Ø25.4	30.2		
350	14	535	476.3	12 × Ø28.6	35.4		
400	16	595	539.8	16 × Ø28.6	37		
450	18	635	577.9	16 × Ø31.8	40.1		
500	20	700	635	20 × Ø31.8	43.3		
600	24	815	749.3	20 × Ø34.9	48.1		

Surface roughness (flange): Ra 6.3 to 12.5 µm

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange according to ASME B16.5, Class 300
Carbon steel: *order code for "Process connection", option* **A2K**
Stainless steel: *order code for "Process connection", option* **A2S**

DN		A	B	C	D	E	L
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
25	1	123.9	88.9	4 × Ø19.1	15.9	1)	2)
40	1 ½	155.4	114.3	4 × Ø22.4	19		
50	2	165.1	127	8 × Ø19.1	20.8		
80	3	209.6	168.1	8 × Ø22.4	26.8		
100	4	254	200.2	8 × Ø22.4	30.2		
150	6	317.5	269.7	12 × Ø22.4	35		
Surface roughness (flange): Ra 6.3 to 12.5 µm							

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange according to JIS B2220, 10K
Carbon steel: *order code for "Process connection", option* **N3K**
Stainless steel: *order code for "Process connection", option* **N3S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
50	155	120	4 × Ø19	16	1)	2)
65	175	140	4 × Ø19	18		
80	185	150	8 × Ø19	18		
100	210	175	8 × Ø19	18		
125	250	210	8 × Ø23	20		
150	280	240	8 × Ø23	22		
200	330	290	12 × Ø23	22		
250	400	355	12 × Ø25	24		
300	445	400	16 × Ø25	24		
Surface roughness (flange): Ra 6.3 to 12.5 µm						

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange according to JIS B2220, 20K
Carbon steel: *order code for "Process connection", option* **N4K**
Stainless steel: *order code for "Process connection", option* **N4S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
25	125	90	4 × Ø19	16	1)	2)
32	135	100	4 × Ø19	18		
40	140	105	4 × Ø19	18		
50	155	120	8 × Ø19	18		
65	175	140	8 × Ø19	20		
80	200	160	8 × Ø23	22		
100	225	185	8 × Ø23	24		

Flange according to JIS B2220, 20K
Carbon steel: *order code for "Process connection", option* **N4K**
Stainless steel: *order code for "Process connection", option* **N4S**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
125	270	225	8 × Ø25	26		
150	305	260	12 × Ø25	28		
200	350	305	12 × Ø25	30		
250	430	380	12 × Ø27	34		
300	480	430	16 × Ø27	36		
Surface roughness (flange): Ra 6.3 to 12.5 µm						

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange according to AWWA, Class D
Order code for "Process connection", option **W1K**

DN [mm]	DN [in]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
700	28	927	863.6	28 × Ø35	33.4	1)	2)
750	30	984	914.4	28 × Ø35	35		
800	32	1060	977.9	28 × Ø42	38.1		
900	36	1168	1085.9	32 × Ø42	41.3		
1000	40	1289	1200.2	36 × Ø42	41.3		
–	42	1346	1257.3	36 × Ø42	44.5		
1200	48	1511	1422.4	44 × Ø42	47.7		
–	54	1683	1593.9	44 × Ø48	54		
–	60	1855	1759	52 × Ø48	57.2		
–	66	2032	1930.4	52 × Ø48	63.5		
1800	72	2197	2095.5	60 × Ø48	66.7		
–	78	2362	2260.6	64 × Ø54	69.9		
–	84	2535	2425.7	64 × Ø54	73.1		
–	90	2705	2717.8	68 × Ø60	76.2		
Surface roughness (flange): Ra 6.3 to 12.5 µm							

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Flange according to AS 2129, Tab. E
Order code for "Process connection", option **M2K**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
80	185	146	4 × Ø18	12	1)	2)
100	215	178	8 × Ø18	13		
150	280	235	8 × Ø22	17		
200	335	292	8 × Ø22	19		
250	405	356	12 × Ø22	22		

Flange according to AS 2129, Tab. E
Order code for "Process connection", option **M2K**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
300	455	406	12 × Ø26	25		
350	525	470	12 × Ø26	30		
400	580	521	12 × Ø26	32		
450	640	584	16 × Ø26	35		
500	705	641	16 × Ø26	38		
600	825	756	16 × Ø33	48		
700	910	845	20 × Ø33	51		
750	995	927	20 × Ø36	54		
800	1060	984	20 × Ø36	54		
900	1175	1092	24 × Ø36	64		
1000	1255	1175	24 × Ø39	67		
1200	1490	1410	32 × Ø39	79		
Surface roughness (flange): Ra 6.3 to 12.5 µm						

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

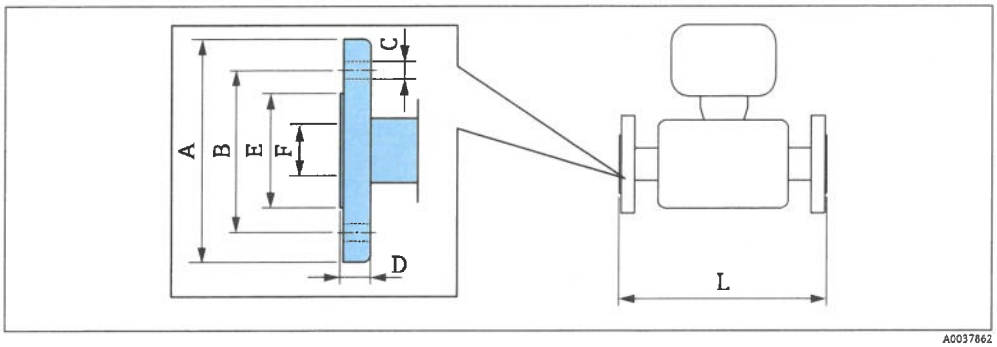
Flange according to AS 4087, PN 16
Order code for "Process connection", option **M3K**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	L [mm]
80	185	146	4 × Ø18	12	1)	2)
100	215	178	4 × Ø18	13		
150	280	235	8 × Ø18	13		
200	335	292	8 × Ø18	19		
250	405	356	8 × Ø22	19		
300	455	406	12 × Ø22	23		
350	525	470	12 × Ø26	30		
375	550	495	12 × Ø26	30		
400	580	521	12 × Ø26	32		
450	640	584	12 × Ø26	30		
500	705	641	16 × Ø26	38		
600	825	756	16 × Ø30	48		
700	910	845	20 × Ø30	56		
750	995	927	20 × Ø33	56		
800	1060	984	20 × Ø36	56		
900	1175	1092	24 × Ø36	66		
1000	1255	1175	24 × Ø36	66		

Flange according to AS 4087, PN 16 *Order code for "Process connection", option* **M3K**						
DN [mm]	**A [mm]**	**B [mm]**	**C [mm]**	**D [mm]**	**E [mm]**	**L [mm]**
1200	1490	1410	32 × Ø36	76		
Surface roughness (flange): Ra 6.3 to 12.5 µm						

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Lap joint flange



Lap joint flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 10 **Carbon steel:** *order code for "Process connection", option* **D22** **Stainless steel:** *order code for "Process connection", option* **D24**								
DN		**A**	**B**	**C**	**D**	**E**	**F**	**L**
[mm]	**[in]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**
200	8	340	295	8 × Ø22	24	264	1)	2)
250	10	395	350	12 × Ø22	26	317		
300	12	445	400	12 × Ø22	26	367		
Surface roughness (flange): Ra 6.3 to 12.5 µm								

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Lap joint flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 16 **Carbon steel:** *order code for "Process connection", option* **D32** **Stainless steel:** *order code for "Process connection", option* **D34**								
DN		**A**	**B**	**C**	**D**	**E**	**F**	**L**
[mm]	**[in]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**	**[mm]**
25	1	115	85	4 × Ø14	16	49	1)	2)
32	-	140	100	4 × Ø18	18	65		
40	1 ½	150	110	4 × Ø18	18	71		
50	2	165	125	4 × Ø18	20	88		
65	-	185	145	8 × Ø18	20	103		
80	3	200	160	8 × Ø18	20	120		
100	4	220	180	8 × Ø18	22	148		
125	-	250	210	8 × Ø18	22	177		

Lap joint flange in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 16
Carbon steel: *order code for "Process connection", option* **D32**
Stainless steel: *order code for "Process connection", option* **D34**

DN		A	B	C	D	E	F	L
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
150	6	285	240	8 × Ø22	24	209		
200	8	340	295	12 × Ø22	26	264		
250	10	405	355	12 × Ø26	29	317		
300	12	460	410	12 × Ø26	32	367		
Surface roughness (flange): Ra 6.3 to 12.5 µm								

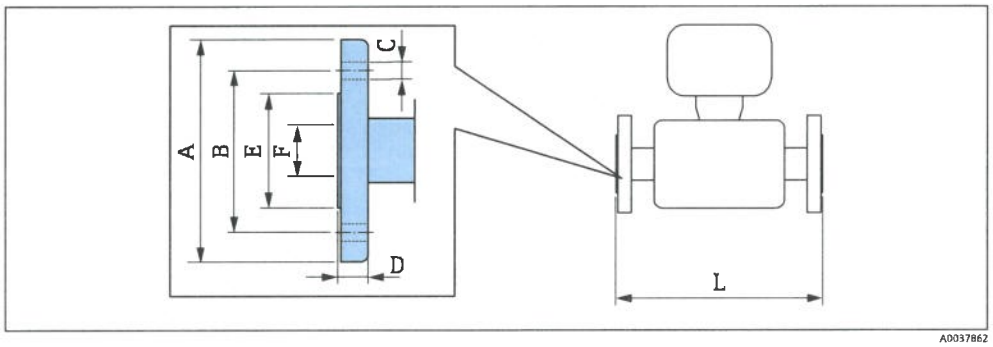
1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Lap joint flange according to ASME B16.5, Class 150
Carbon steel: *order code for "Process connection", option* **A12**
Stainless steel: *order code for "Process connection", option* **A14**

DN		A	B	C	D	E	F	L
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]
25	1	110	80	4 × Ø16	14	49	1)	2)
40	1 ½	125	98	4 × Ø16	17.5	71		
50	2	150	121	4 × Ø19	19	88		
80	3	190	152	4 × Ø19	24	120		
100	4	230	190	8 × Ø19	24	148		
150	6	280	241	8 × Ø23	25	209		
200	8	345	298	8 × Ø23	29	264		
250	10	405	362	12 × Ø25	30	317		
300	12	485	432	12 × Ø25	32	378		
Surface roughness (flange): Ra 6.3 to 12.5 µm								

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Lap joint flange, stamped plate



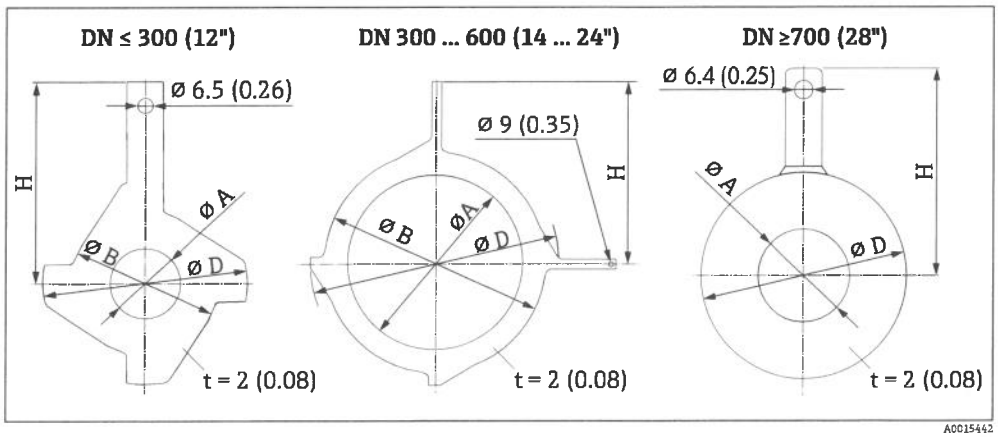
Lap joint flange, stamped plate in accordance with EN 1092-1 (DIN 2501 / DIN 2512N): PN 10
Carbon steel: *order code for "Process connection", option* **D21**
Stainless steel: *order code for "Process connection", option* **D23**

DN [mm]	A [mm]	B [mm]	C [mm]	D [mm]	E [mm]	F [mm]	L [mm]
25	115	85	4 x Ø13.5	16.5	49	1)	2)
32	140	100	4 x Ø17.5	17	65		
40	150	110	4 x Ø17.5	16.5	71		
50	165	125	4 x Ø17.5	18.5	88		
65	185	145	4 x Ø17.5	20	103		
80	200	160	8 x Ø17.5	23.5	120		
100	220	180	8 x Ø17.5	24.5	148		
125	250	210	8 x Ø17.5	24	177		
150	285	240	8 x Ø21.5	25	209		
200	340	295	8 x Ø21.5	27.5	264		
250	405	350	12 x Ø21.5	30.5	317		
300	445	400	12 x Ø21.5	34.5	367		
Surface roughness (flange): Ra 6.3 to 12.5 µm							

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 50 (compact version) → 🖹 53 (remote version)

Accessories

Ground disks for flange connections



DN [mm]	DN [inch]	Pressure rating	A [mm]	A [inch]	B [mm]	B [inch]	D [mm]	D [inch]	H [mm]	H [inch]
25	1"	1)	26	1.02	62	2.44	77.5	3.05	87.5	3.44
32	1 ¼"	1)	35	1.38	80	3.15	87.5	3.44	94.5	3.72
40	1 ½"	1)	41	1.61	82	3.23	101	3.98	103	4.06
50	2"	1)	52	2.05	101	3.98	115.5	4.55	108	4.25
65	2 ½"	1)	68	2.68	121	4.76	131.5	5.18	118	4.65
80	3"	1)	80	3.15	131	5.16	154.5	6.08	135	5.31

DN		Pressure rating	A		B		D		H	
[mm]	[inch]		[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]
100	4"	1)	104	4.09	156	6.14	186.5	7.34	153	6.02
125	5"	1)	130	5.12	187	7.36	206.5	8.13	160	6.30
150	6"	1)	158	6.22	217	8.54	256	10.08	184	7.24
200	8"	1)	206	8.11	267	10.51	288	11.34	205	8.07
250	10"	1)	260	10.24	328	12.91	359	14.13	240	9.45
300	12"	PN 10 PN 16 Cl. 150	312	12.28	375	14.76	413	16.26	273	10.75
		PN 25 JIS 10K JIS 20K	310	12.20	375	14.76	404	15.91	268	10.55
350	14"	PN 6	343	13.50	420	16.54	479	18.86	365	14.37
		PN 10								
		PN 16								
375	15"	PN 16	393	15.5	461	18.2	523	20.6	395	15.6
400	16"	PN 6	393	15.5	470	18.50	542	21.34	395	15.55
		PN 10								
		PN 16								
450	18"	PN 6	439	17.28	525	20.67	583	22.95	417	16.42
		PN 10								
		PN 16								
500	20"	PN 6	493	19.41	575	22.64	650	25.59	460	18.11
		PN 10								
		PN 16								
600	24"	PN 6	593	23.35	676	26.61	766	30.16	522	20.55
		PN 10								
		PN 16								
700	28"	PN 6	697	27.44	–	–	786	30.94	460	18.11
		PN10	693	27.28	–	–	813	32.01	480	18.9
		PN16	687	27.05	–	–	807	31.77	490	19.29
		Cl, D	693	27.28	–	–	832	32.76	494	19.45
750	30"	Cl, D	743	29.25	–	–	833	32.8	523	20.59
800	32"	PN 6	799	31.46	–	–	893	35.16	520	20.47
		PN 10	795	31.3	–	–	920	36.22	540	21.26
		PN 16	789	31.06	–	–	914	35.98	550	21.65
		Cl, D	795	31.3	–	–	940	37.01	561	22.09
900	36"	PN 6	897	35.31	–	–	993	39.09	570	22.44
		PN 10	893	35.16	–	–	1020	40.16	590	23.23
		PN 16	886	34.88	–	–	1014	39.92	595	23.43
		Cl, D	893	35.16	–	–	1048	41.26	615	24.21
1000	40"	PN 6	999	39.33	–	–	1093	43.03	620	24.41
		PN 10	995	39.17	–	–	1127	44.37	650	25.59
		PN 16	988	38.9	–	–	1131	44.53	660	25.98

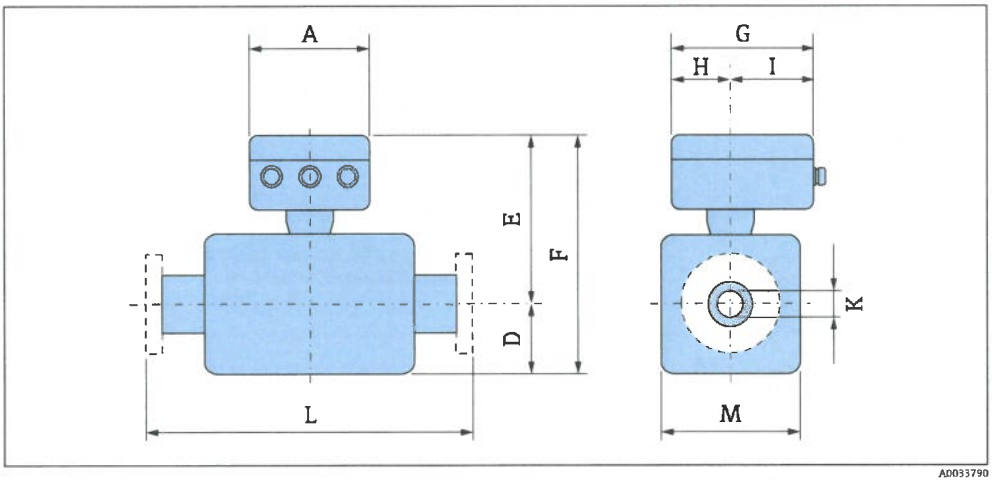
DN		Pressure rating	A		B		D		H	
[mm]	[inch]		[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]
		Cl, D	995	39.17	–	–	1163	45.79	675	26.57
–	42"	PN 6	1044	41.1	–	–	1220	48.03	704	27.72
1200	48"	PN 6	1203	47.36	–	–	1310	51.57	733	28.86
		PN 10	1196	47.09	–	–	1344	52.91	760	29.92
		PN 16	1196	47.09	–	–	1385	54.53	786	30.94
		Cl, D	1188	46.77	–	–	1345	52.95	775	30.51

1) In the case of DN 25 to 250, ground disks can be used for all the flange standards/pressure ratings which can be supplied in the standard version

Dimensions in US units

Compact version

Order code for "Housing", option A "Compact, aluminum, coated" or option M "Compact, polycarbonate"



A [in]	G [1] [in]	H [in]	I [1] [in]
6.57	7.60	3.54	4.06

1) Depending on the cable gland used: values up to + 1.18 in

DN 25 to 300 (1 to 12"): sensor with aluminum half-shell housing

DN		Order code for "Design"								K	L
		Options A, D, E, H, I				Option C					
		D [1]	E [1] [2]	F [1] [2]	M [1]	D [1]	E [1] [2]	F [1] [2]	M [1]		
[mm]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]
25	1	3.31	7.91	11.22	4.72	–	–	–	–	[3]	7.87
32	–	3.31	7.91	11.22	4.72	–	–	–	–	[3]	7.87
40	1 ½	3.31	7.91	11.22	4.72	–	–	–	–	[3]	7.87
50	2	3.31	7.91	11.22	4.72	3.31	7.91	11.22	4.72	[3]	7.87
65	–	4.29	8.9	13.19	7.09	3.31	7.91	11.22	4.72	[3]	7.87
80	3	4.29	8.9	13.19	7.09	3.31	7.91	11.22	4.72	[3]	7.87
100	4	4.29	8.9	13.19	7.09	4.29	8.9	13.19	7.09	[3]	9.84
125	–	5.91	10.47	16.38	10.24	4.29	8.9	13.19	7.09	[3]	9.84
150	6	5.91	10.47	16.38	10.24	4.29	8.9	13.19	7.09	[3]	11.81
200	8	7.09	11.46	18.54	12.76	5.91	10.47	16.38	10.24	[3]	13.78
250	10	8.07	12.44	20.51	15.75	5.91	10.47	16.38	10.24	[3]	17.72
300	12	9.06	13.43	22.48	18.11	7.09	11.46	18.54	12.76	[3]	19.69

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) With order code for "Sensor option", option CG "Sensor extended neck for insulation": values + 4.33 in
3) Depends on the liner→ 81

DN 350 to 900 (14 to 36")

DN		Order code for "Design"								K	L	
		Options A, E, F				Option B, G						
		D [1]	E [1) 2)]	F [1) 2)]	M [1)]	D [1)]	E [1) 2)]	F [1) 2)]	M [1)]			
[mm]	[in]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	
350	14	9.65	16.2	25.91	19.29	–	–	–	–	3)	21.65	
375	15	10.67	17.24	27.91	21.34	–	–	–	–	3)	21.65	
400	16	10.67	17.24	27.91	21.34	–	–	–	–	3)	23.62	
450	18	11.77	18.35	30.12	23.54	13.11	17.72	30.83	26.22	3)	23.62 [4)]	25.59 [5)]
500	20	12.76	19.33	32.09	25.51	14.13	18.7	32.83	28.23	3)	23.62 [4)]	25.59 [5)]
600	24	14.37	21.34	35.71	28.74	16.18	20.79	36.97	32.32	3)	23.62 [4)]	30.71 [5)]
700	28	16.93	23.74	40.67	33.86	20.16	24.8	44.96	40.31	3)	27.56 [4)]	35.83 [5)]
750	30	18.39	25.24	43.62	36.77	20.16	24.8	44.96	40.31	3)	27.56 [4)]	35.83 [5)]
800	32	19.13	25.98	45.12	38.27	21.02	25.59	46.61	41.93	3)	31.5 [4)]	40.94 [5)]
900	36	21.1	27.95	49.06	42.2	24.02	28.62	52.64	47.95	3)	35.43 [4)]	46.06 [5)]

1) The dimensions are reference values. They may be different than indicated, depending on the pressure rating, design and order code.
2) With order code for "Sensor option", option CG "Sensor extended neck for insulation": values + 110 mm
3) Depends on the liner→ 🖹 81
4) Order code for "Design", option F "Fixed flange, short installation length"
5) Order code for "Design", option G "Fixed flange, long installation length"

DN 1000 to 2400 (40 to 90")

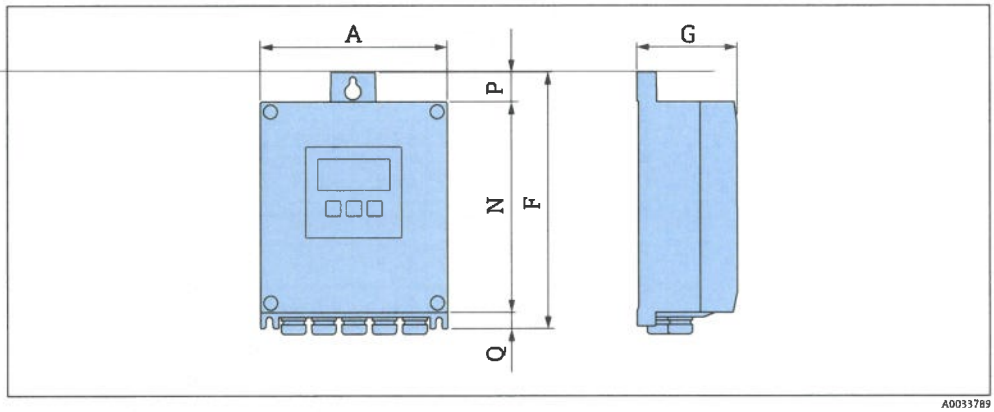
DN		D [1)]	E [1) 2)]	F [1) 2)]	K	L		M [1)]
[mm]	[in]	[in]	[in]	[in]	[in]	[in]		[in]
1000	40	27.01	31.61	58.62	3)	39.37 [4)]	51.18 [5)]	53.94
–	42	28.03	32.6	60.63	3)	41.34 [4)]	53.74 [5)]	55.91
1200	48	31.93	36.57	68.5	3)	47.24 [4)]	61.42 [5)]	63.78
–	54	35.91	40.51	76.42	3)	53.15 [4)]	69.09 [5)]	71.65
1400	–	38.86	43.46	82.32	3)	55.12 [4)]	71.65 [5)]	77.56
–	60	39.8	44.41	84.21	3)	59.06 [4)]	76.77 [5)]	79.45
1600	–	41.57	46.18	87.76	3)	62.99 [4)]	81.89 [5)]	82.99
–	66	43.03	47.6	90.63	3)	64.96 [4)]	84.45 [5)]	85.83
1800	72	46.77	51.34	98.11	3)	70.87 [4)]	92.13 [5)]	93.31
–	78	48.74	53.31	102.05	3)	78.74 [4)]	102.36 [5)]	97.24
2000	–	48.74	53.31	102.05	3)	78.74 [4)]	102.36 [5)]	97.24
–	84	48.74	53.31	102.05	3)	86.61 [4)]		97.24
2200	–	48.31	52.99	101.3	3)	86.61 [4)]		96.61
–	90	48.31	52.99	101.3	3)	94.49 [4)]		96.61
2400	–	52.44	57.13	109.57	3)	94.49 [4)]		104.88

1) The dimensions are reference values. They may be different than indicated, depending on the pressure rating, design and order code.
2) With order code for "Sensor option", option CG "Sensor extended neck for insulation": values + 4.33 in
3) Depends on the liner→ 🖹 81
4) Order code for "Design", option F "Fixed flange, short installation length"
5) Order code for "Design", option G "Fixed flange, long installation length"

Remote version

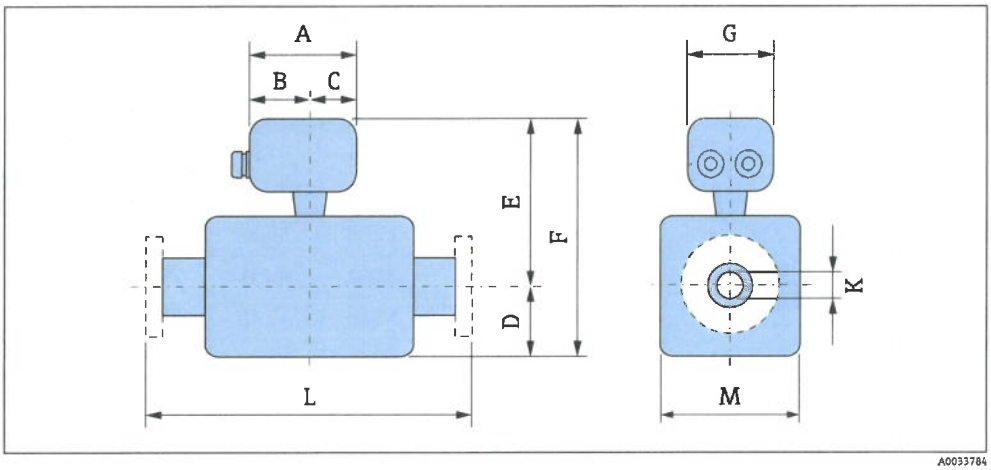
Transmitter remote version

Order code for "Housing", option N "Remote, polycarbonate" or option P "Remote, aluminum coated"



A [in]	F [in]	G [in]	N [in]	P [in]	Q [in]
6.57	9.13	3.15	7.36	0.94	0.83

Sensor connection housing



Aluminum, coated

A [in]	B [in]	C [in]	G [in]
5.83	3.7	2.13	5.35

Polycarbonate (only in conjunction with order code for "Sensor option", options CA...CE)

A [in]	B [in]	C [in]	G [in]
4.45	2.44	2.01	4.41

DN 25 to 300 (1 to 12"): sensor with aluminum half-shell housing

DN		Order code for "Design"								K	L
		Options A, D, E, H, I				Option C					
		D [1]	E [1]	F [1]	M [1]	D [1]	E [1]	F [1]	M [1]		
[mm]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]
25	1	3.31	7.87	11.18	4.72	–	–	–	–	[2]	7.87
32	–	3.31	7.87	11.18	4.72	–	–	–	–	[2]	7.87
40	1 ½	3.31	7.87	11.18	4.72	–	–	–	–	[2]	7.87
50	2	3.31	7.87	11.18	4.72	3.31	7.87	11.18	4.72	[2]	7.87
65	–	4.29	8.86	13.15	7.09	3.31	7.87	11.18	4.72	[2]	7.87
80	3	4.29	8.86	13.15	7.09	3.31	7.87	11.18	4.72	[2]	7.87
100	4	4.29	8.86	13.15	7.09	4.29	8.86	13.15	7.09	[2]	9.84
125	–	5.91	10.43	16.34	10.24	4.29	8.86	13.15	7.09	[2]	9.84
150	6	5.91	10.43	16.34	10.24	4.29	8.86	13.15	7.09	[2]	11.81
200	8	7.09	11.42	18.5	12.76	5.91	10.43	16.34	10.24	[2]	13.78
250	10	8.07	12.4	20.47	15.75	5.91	10.43	16.34	10.24	[2]	17.72
300	12	9.06	13.39	22.44	18.11	7.09	11.42	18.5	12.76	[2]	19.69

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) Depends on the liner→ 🖹 81

DN 25 to 300 (1 to 12"): sensor with fully welded carbon steel housing

DN		Order code for "Design"								K	L
		Options A, E				Option C					
		D [1]	E [1]	F [1]	M [1]	D [1]	E [1]	F [1]	M [1]		
[mm]	[in]	[mm]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]
25	1	2.76	7.87	10.63	5.51	–	–	–	–	[2]	7.87
32	–	2.76	7.87	10.63	5.51	–	–	–	–	[2]	7.87
40	1 ½	2.76	7.87	10.63	5.51	–	–	–	–	[2]	7.87
50	2	2.76	7.87	10.63	5.51	2.76	7.87	10.63	5.51	[2]	7.87
65	–	3.23	8.86	12.09	6.5	2.76	7.87	10.63	5.51	[2]	7.87
80	3	3.43	8.86	12.28	6.89	2.76	7.87	10.63	5.51	[2]	7.87
100	4	3.94	8.86	12.8	7.87	3.23	8.86	12.09	6.5	[2]	9.84
125	–	4.45	10.43	14.88	8.9	3.43	8.86	12.28	6.89	[2]	9.84
150	6	5.28	10.43	15.71	10.59	3.94	8.86	12.8	7.87	[2]	11.81
200	8	6.3	11.42	17.72	12.6	4.45	10.43	14.88	8.9	[2]	13.78
250	10	7.6	12.4	20	15.24	5.28	10.43	15.71	10.59	[2]	17.72
300	12	8.58	13.39	21.97	17.2	6.3	11.42	17.72	12.6	[2]	19.69

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) Depends on the liner→ 🖹 81

DN 350 to 900 (14 to 36")

DN		Order code for "Design"								K	L	
		Options A, E, F				Option B, G						
		D [1]	E [1]	F [1]	M [1]	D [1]	E [1]	F [1]	M [1]			
[mm]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	
350	14	9.65	13.78	23.43	19.29	–	–	–	–	[2]	21.65	
375	15	10.67	14.76	25.43	21.34	–	–	–	–	[2]	21.65	
400	16	10.67	14.76	25.43	21.34	–	–	–	–	[2]	23.62	
450	18	11.77	15.87	27.64	23.54	13.11	17.6	30.71	26.22	[2]	23.62 [3]	25.59 [4]
500	20	12.76	16.85	29.61	25.51	14.13	18.58	32.72	28.23	[2]	23.62 [3]	25.59 [4]
600	24	14.37	18.86	33.23	28.74	16.18	20.67	36.85	32.32	[2]	23.62 [3]	30.71 [4]
700	28	16.93	21.26	38.19	33.86	20.16	24.69	44.84	40.31	[2]	27.56 [3]	35.83 [4]
750	30	18.39	22.76	41.14	36.77	20.16	24.69	44.84	40.31	[2]	27.56 [3]	35.83 [4]
800	32	19.13	23.5	42.64	38.27	21.02	25.47	46.5	41.93	[2]	31.5 [3]	40.94 [4]
900	36	21.1	25.47	46.57	42.2	24.02	28.5	52.52	47.95	[2]	35.43 [3]	46.06 [4]

1) The dimensions are reference values. They may vary depending on the pressure rating, design and order option.
2) Depends on the liner→ 🖹 81
3) Order code for "Design", option F "Fixed flange, short installation length"
4) Order code for "Design", option G "Fixed flange, long installation length"

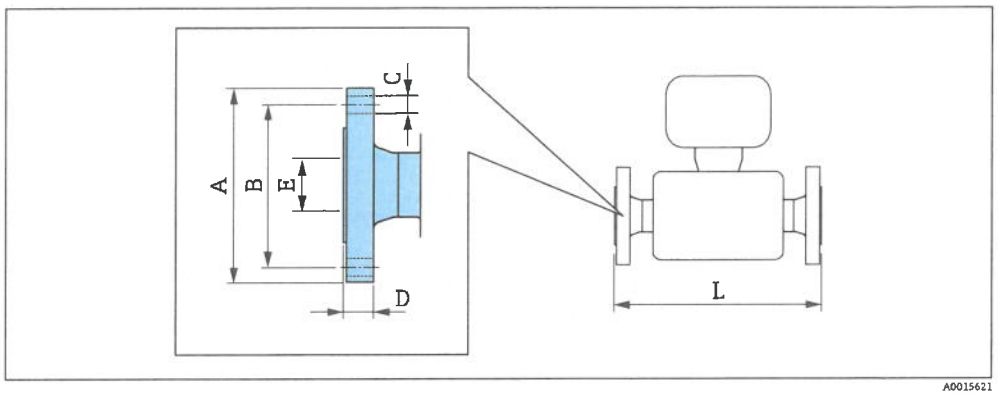
1000 ... 2400 (40 ... 90")

DN		D [1]	E [1]	F [1]	K	L		M [1]
[mm]	[in]	[in]	[in]	[in]	[in]	[in]		[in]
1000	40	27.01	31.5	58.5	[2]	39.37 [3]	51.18 [4]	53.94
–	42	28.03	32.48	60.51	[2]	41.34 [3]	53.74 [4]	55.91
1200	48	31.93	36.46	68.39	[2]	47.24 [3]	61.42 [4]	63.78
–	54	35.91	40.39	76.3	[2]	53.15 [3]	69.09 [4]	71.65
1400	–	38.86	43.35	82.2	[2]	55.12 [3]	71.65 [4]	77.56
–	60	39.8	44.29	84.09	[2]	59.06 [3]	76.77 [4]	79.45
1600	–	41.57	46.06	87.64	[2]	62.99 [3]	81.89 [4]	82.99
–	66	43.03	47.48	90.51	[2]	64.96 [3]	84.45 [4]	85.83
1800	72	46.77	51.22	97.99	[2]	70.87 [3]	92.13 [4]	93.31
–	78	48.74	53.19	101.93	[2]	78.74 [3]	102.36 [4]	97.24
2000	–	48.74	53.19	101.93	[2]	78.74 [3]	102.36 [4]	97.24
–	84	48.74	53.19	101.93	[2]	86.61 [3]		97.24
2200	–	48.31	52.87	101.18	[2]	86.61 [3]		96.61
–	90	48.31	52.87	101.18	[2]	94.49 [3]		96.61
2400	–	52.44	57.01	109.45	[2]	94.49 [3]		104.88

1) The dimensions are reference values. They may be different than indicated, depending on the pressure rating, design and order code.
2) Internal diameter depends on liner, see measuring tube specification → 🖹 81
3) Order code for "Design", option F "Fixed flange, short installation length"
4) Order code for "Design", option G "Fixed flange, long installation length"

Flange connections

Fixed flange



Flange according to ASME B16.5, Class 150 **Carbon steel:** *order code for "Process connection", option* **A1K** **Stainless steel:** *order code for "Process connection", option* **A1S**							
DN		**A**	**B**	**C**	**D**	**E**	**L**
[mm]	**[in]**	**[in]**	**[in]**	**[in]**	**[in]**	**[in]**	**[in]**
25	1	4.25	3.12	4 × Ø0.63	0.5	1)	2)
40	1 ½	5	3.88	4 × Ø0.63	0.63		
50	2	6	4.75	4 × Ø0.75	0.69		
80	3	7.5	6	4 × Ø0.75	0.88		
100	4	9	7.5	8 × Ø0.75	0.88		
150	6	11	9.5	8 × Ø0.88	0.94		
200	8	13.5	11.75	8 × Ø0.88	1.06		
250	10	16	14.25	12 × Ø1	1.17		
300	12	19	17	12 × Ø1	1.19		
350	14	21.06	18.75	12 × Ø1.13	1.39		
400	16	23.43	21.25	16 × Ø1.13	1.46		
450	18	25	22.75	16 × Ø1.25	1.58		
500	20	27.56	25	20 × Ø1.25	1.7		
600	24	32.09	29.5	20 × Ø1.37	1.89		
Surface roughness (flange): Ra 250 to 492 µm							

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 68 (compact version) → 🖹 70 (remote version)

Flange according to ASME B16.5, Class 300 **Carbon steel:** *order code for "Process connection", option* **A2K** **Stainless steel:** *order code for "Process connection", option* **A2S**							
DN		**A**	**B**	**C**	**D**	**E**	**L**
[in]	**[mm]**	**[in]**	**[in]**	**[in]**	**[in]**	**[in]**	**[in]**
1	25	4.88	3.5	4 × Ø0.75	0.63	1)	2)
1 ½	40	6.12	4.5	4 × Ø0.88	0.75		
2	50	6.5	5	8 × Ø0.75	0.82		

Flange according to ASME B16.5, Class 300
Carbon steel: *order code for "Process connection", option* **A2K**
Stainless steel: *order code for "Process connection", option* **A2S**

DN		A	B	C	D	E	L
[in]	[mm]	[in]	[in]	[in]	[in]	[in]	[in]
3	80	8.25	6.62	8 × Ø0.88	1.06		
4	100	10	7.88	8 × Ø0.88	1.19		
6	150	12.5	10.62	12 × Ø0.88	1.38		
Surface roughness (flange): Ra 250 to 492 µm							

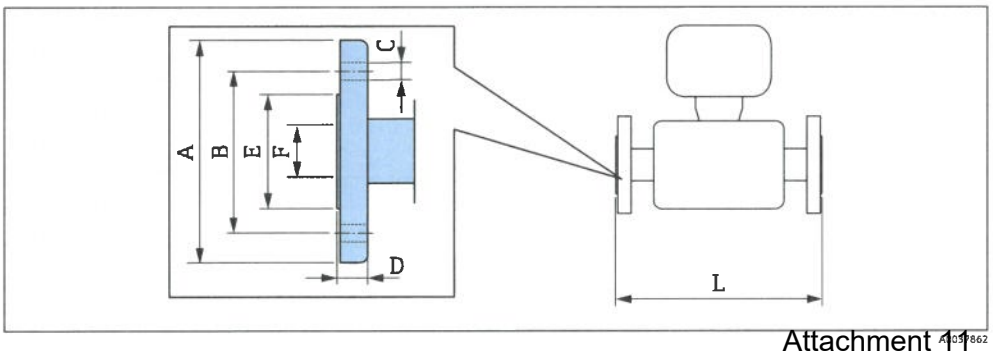
1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 68 (compact version) → 🖹 70 (remote version)

Flange according to AWWA, Cl. D
Order code for "Process connection", option **W1K**

DN		A	B	C	D	E	L
[in]	[mm]	[in]	[in]	[in]	[in]	[in]	[in]
28	700	36.5	34	28 × Ø1.38	1.31	1)	2)
30	–	38.74	36	28 × Ø1.38	1.38		
32	800	41.73	38.5	28 × Ø1.65	1.5		
36	900	45.98	42.75	32 × Ø1.65	1.63		
40	1000	50.75	47.25	36 × Ø1.65	1.63		
42	–	52.99	49.5	36 × Ø1.65	1.75		
48	1200	59.49	56	44 × Ø1.65	1.88		
54	–	66.26	62.75	44 × Ø1.89	2.13		
60	–	73.03	69.25	52 × Ø1.89	2.25		
66	–	80	76	52 × Ø48	2.5		
72	1800	86.5	82.5	60 × Ø48	2.63		
78	–	92.99	89	64 × Ø54	2.75		
84	–	99.8	95.5	64 × Ø54	2.88		
90	–	106.5	107	68 × Ø60	3		
Surface roughness (flange): Ra 250 to 492 µin							

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 68 (compact version) → 🖹 70 (remote version)

Lap joint flange



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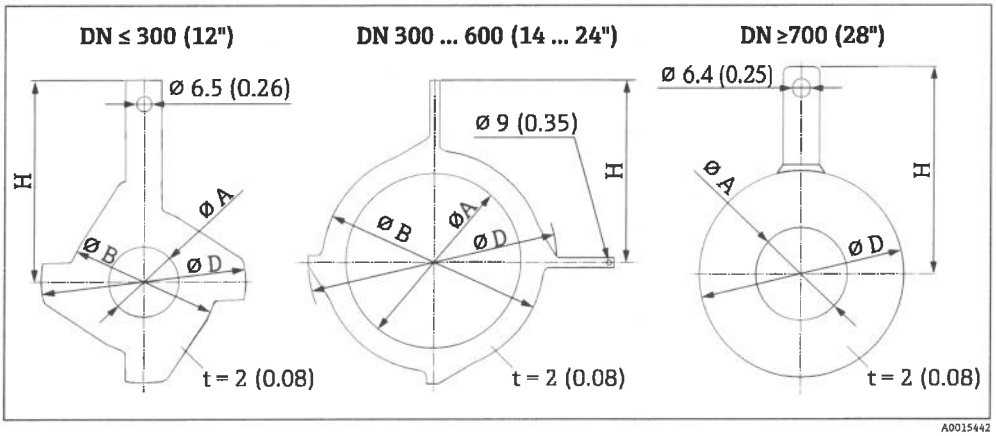
Lap joint flange according to ASME B16.5, Class 150
Carbon steel: *order code for "Process connection", option* **A12**
Stainless steel: *order code for "Process connection", option* **A14**

DN		A	B	C	D	E	F	L
[mm]	[in]	[in]	[in]	[in]	[in]	[in]	[in]	[in]
25	1	4.33	3.15	4 × Ø0.63	0.55	1.93	1)	2)
40	1 ½	4.92	3.86	4 × Ø0.63	0.69	2.8		
50	2	5.91	4.76	4 × Ø0.75	0.75	3.46		
80	3	7.48	5.98	4 × Ø0.75	0.94	4.72		
100	4	9.06	7.48	8 × Ø0.75	0.94	5.83		
150	6	11.02	9.49	8 × Ø0.91	0.98	8.23		
200	8	13.58	11.73	8 × Ø0.91	1.14	10.39		
250	10	15.94	14.25	12 × Ø0.98	1.18	12.48		
300	12	19.09	17.01	12 × Ø0.98	1.26	14.88		
Surface roughness (flange): Ra 248 to 492 µin								

1) Depends on the liner→ 🖹 81
2) Total length is independent of the process connections. Length according to DVGW (German Technical and Scientific Association for Gas and Water) → 🖹 68 (compact version) → 🖹 70 (remote version)

Accessories

Ground disks for flange connections



DN		Pressure rating	A		B		D		H	
[mm]	[inch]		[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]
25	1"	1)	26	1.02	62	2.44	77.5	3.05	87.5	3.44
32	1 ¼"	1)	35	1.38	80	3.15	87.5	3.44	94.5	3.72
40	1 ½"	1)	41	1.61	82	3.23	101	3.98	103	4.06
50	2"	1)	52	2.05	101	3.98	115.5	4.55	108	4.25
65	2 ½"	1)	68	2.68	121	4.76	131.5	5.18	118	4.65
80	3"	1)	80	3.15	131	5.16	154.5	6.08	135	5.31
100	4"	1)	104	4.09	156	6.14	186.5	7.34	153	6.02
125	5"	1)	130	5.12	187	7.36	206.5	8.13	160	6.30

DN		Pressure rating	A		B		D		H	
[mm]	[inch]		[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]
150	6"	1)	158	6.22	217	8.54	256	10.08	184	7.24
200	8"	1)	206	8.11	267	10.51	288	11.34	205	8.07
250	10"	1)	260	10.24	328	12.91	359	14.13	240	9.45
300	12"	PN 10 PN 16 Cl. 150	312	12.28	375	14.76	413	16.26	273	10.75
		PN 25 JIS 10K JIS 20K	310	12.20	375	14.76	404	15.91	268	10.55
350	14"	PN 6	343	13.50	420	16.54	479	18.86	365	14.37
		PN 10								
		PN 16								
375	15"	PN 16	393	15.5	461	18.2	523	20.6	395	15.6
400	16"	PN 6	393	15.5	470	18.50	542	21.34	395	15.55
		PN 10								
		PN 16								
450	18"	PN 6	439	17.28	525	20.67	583	22.95	417	16.42
		PN 10								
		PN 16								
500	20"	PN 6	493	19.41	575	22.64	650	25.59	460	18.11
		PN 10								
		PN 16								
600	24"	PN 6	593	23.35	676	26.61	766	30.16	522	20.55
		PN 10								
		PN 16								
700	28"	PN 6	697	27.44	–	–	786	30.94	460	18.11
		PN10	693	27.28	–	–	813	32.01	480	18.9
		PN16	687	27.05	–	–	807	31.77	490	19.29
		Cl, D	693	27.28	–	–	832	32.76	494	19.45
750	30"	Cl, D	743	29.25	–	–	833	32.8	523	20.59
800	32"	PN 6	799	31.46	–	–	893	35.16	520	20.47
		PN 10	795	31.3	–	–	920	36.22	540	21.26
		PN 16	789	31.06	–	–	914	35.98	550	21.65
		Cl, D	795	31.3	–	–	940	37.01	561	22.09
900	36"	PN 6	897	35.31	–	–	993	39.09	570	22.44
		PN 10	893	35.16	–	–	1020	40.16	590	23.23
		PN 16	886	34.88	–	–	1014	39.92	595	23.43
		Cl, D	893	35.16	–	–	1048	41.26	615	24.21
1000	40"	PN 6	999	39.33	–	–	1093	43.03	620	24.41
		PN 10	995	39.17	–	–	1127	44.37	650	25.59
		PN 16	988	38.9	–	–	1131	44.53	660	25.98
		Cl, D	995	39.17	–	–	1163	45.79	675	26.57
–	42"	PN 6	1044	41.1	–	–	1220	48.03	704	27.72

DN		Pressure rating	A		B		D		H	
[mm]	[inch]		[mm]	[inch]	[mm]	[inch]	[mm]	[inch]	[mm]	[inch]
1200	48"	PN 6	1203	47.36	–	–	1310	51.57	733	28.86
		PN 10	1196	47.09	–	–	1344	52.91	760	29.92
		PN 16	1196	47.09	–	–	1385	54.53	786	30.94
		Cl, D	1188	46.77	–	–	1345	52.95	775	30.51

1) In the case of DN 25 to 250, ground disks can be used for all the flange standards/pressure ratings which can be supplied in the standard version

Weight

All values (weight exclusive of packaging material) refer to devices with flanges of the standard pressure rating.
The weight may be lower than indicated depending on the pressure rating and design.

Weight in SI units

Order code for "Design", options A, B, C, D, E DN 25 to 400, DN 1" to 16"				
Nominal diameter		Reference values		
		EN (DIN), AS, JIS		ASME (Class 150)
[mm]	[in]	Pressure rating	[kg]	[kg]
25	1	PN 40	10	5
32	–	PN 40	11	–
40	1 ½	PN 40	12	7
50	2	PN 40	13	9
65	–	PN 16	13	–
80	3	PN 16	15	14
100	4	PN 16	18	19
125	–	PN 16	25	–
150	6	PN 16	31	33
200	8	PN 10	52	52
250	10	PN 10	81	90
300	12	PN 10	95	129
350	14	PN 6	106	172
375	15	PN 6	121	–
400	16	PN 6	121	203

Order code for "Design", options A, F ≥ DN 450 (18")				
Nominal diameter		Reference values		
		EN (DIN) (PN16)	AS (PN 16)	ASME (Class 150), AWWA (Class D)
[mm]	[in]	[kg]	[kg]	[kg]
450	18	142	138	191
500	20	182	186	228
600	24	227	266	302
700	28	291	369	266
–	30	–	447	318
800	32	353	524	383
900	36	444	704	470
1000	40	566	785	587
–	42	–	–	670
1200	48	843	1229	901
–	54	–	–	1273
1400	–	1204	–	–
–	60	–	–	1594

Order code for "Design", options A, F ≥ DN 450 (18")				
Nominal diameter		Reference values		
		EN (DIN) (PN16)	AS (PN 16)	ASME (Class 150), AWWA (Class D)
[mm]	[in]	[kg]	[kg]	[kg]
1600	–	1845	–	–
–	66	–	–	2131
1800	72	2357	–	2568
–	78	2929	–	3113
2000	–	2929	–	3113
–	84	–	–	3755
2200	–	3422	–	–
–	90	–	–	4797
2400	–	4094	–	–

Order code for "Design", options B, G ≥ DN 450 (18")			
Nominal diameter		Reference values	
		EN (DIN) (PN 6)	ASME (Class 150), AWWA (Class D)
[mm]	[in]	[kg]	[kg]
450	18	161	255
500	20	156	285
600	24	208	405
700	28	304	400
–	30	–	460
800	32	357	550
900	36	485	800
1000	40	589	900
–	42	–	1100
1200	48	850	1400
–	54	850	2200
1400	–	1300	–
–	60	–	2700
1600	–	1845	–
–	66	–	3700
1800	72	2357	4100
–	78	2929	4600
2000	–	2929	–

Weight in US units

Order code for "Design", options A, B, C, D, E DN 25 to 400, DN 1" to 16"		
Nominal diameter		Reference values ASME (Class 150)
[mm]	[in]	[lb]
25	1	11
32	–	–
40	1 ½	15
50	2	20
65	–	–
80	3	31
100	4	42
125	–	–
150	6	73
200	8	115
250	10	198
300	12	284
350	14	379
375	15	–
400	16	448

Order code for "Design", options A, F ≥ DN 450 (18")		
Nominal diameter		Reference values ASME (Class 150), AWWA (Class D)
[mm]	[in]	[lb]
450	18	421
500	20	503
600	24	666
700	28	587
–	30	701
800	32	845
900	36	1036
1000	40	1294
–	42	1477
1200	48	1987
–	54	2807
1400	–	–
–	60	3515
1600	–	–
–	66	4699
1800	72	5662
–	78	6864
2000	–	6864

Order code for "Design", options A, F ≥ DN 450 (18")		
Nominal diameter		Reference values ASME (Class 150), AWWA (Class D)
[mm]	[in]	[lb]
–	84	8280
2200	–	–
–	90	10577
2400	–	–

Order code for "Design", options B, G ≥ DN 450 (18")		
Nominal diameter		Reference values ASME (Class 150), AWWA (Class D)
[mm]	[in]	[lb]
450	18	562
500	20	628
600	24	893
700	28	882
–	30	1014
800	32	1213
900	36	1764
1000	40	1984
–	42	2426
1200	48	3087
–	54	4851
1400	–	–
–	60	5954
1600	–	–
–	66	8158
1800	72	9040
–	78	10143
2000	–	–

Measuring tube specification

Nominal diameter		Pressure rating				Measuring tube internal diameter					
		EN (DIN)	ASME AWWA	AS 2129 AS 4087	JIS	Hard rubber		Polyurethane		PTFE	
[mm]	[in]					[mm]	[in]	[mm]	[in]	[mm]	[in]
25	1	PN 40	Class 150	–	20K	–	–	24	0.94	25	0.98
32	–	PN 40	–	–	20K	–	–	32	1.26	34	1.34
40	1 ½	PN 40	Class 150	–	20K	–	–	38	1.50	40	1.57
50	2	PN 40	Class 150	Table E, PN 16	10K	50	1.97	50	1.97	52	2.05
50 [1)]	2	PN 40	Class 150	Table E, PN 16	10K	32	1.26	–	–	–	–
65	–	PN 16	–	–	10K	66	2.60	66	2.60	68	2.68

Nominal diameter		Pressure rating				Measuring tube internal diameter					
		EN (DIN)	ASME AWWA	AS 2129 AS 4087	JIS	Hard rubber		Polyurethane		PTFE	
[mm]	[in]					[mm]	[in]	[mm]	[in]	[mm]	[in]
65 [1]	–	PN 16	–	–	10K	38	1.50	–	–	–	–
80	3	PN 16	Class 150	Table E, PN 16	10K	79	3.11	79	3.11	80	3.15
80 [1]	3	PN 16	Class 150	Table E, PN 16	10K	50	1.97	–	–	–	–
100	4	PN 16	Class 150	Table E, PN 16	10K	102	4.02	102	4.02	104	4.09
100 [1]	4	PN 16	Class 150	Table E, PN 16	10K	66	2.60	–	–	–	–
125	–	PN 16	–	–	10K	127	5.00	127	5.00	130	5.12
125 [1]	–	PN 16	–	–	10K	79	3.11	–	–	–	–
150	6	PN 16	Class 150	Table E, PN 16	10K	156	6.14	156	6.14	156	6.14
150 [1]	6	PN 16	Class 150	Table E, PN 16	10K	102	4.02	–	–	–	–
200	8	PN 10	Class 150	Table E, PN 16	10K	204	8.03	204	8.03	202	7.95
200 [1]	8	PN 16	Class 150	Table E, PN 16	10K	127	5.00	–	–	–	–
250	10	PN 10	Class 150	Table E, PN 16	10K	258	10.2	258	10.2	256	10.08
250 [1]	10	PN 16	Class 150	Table E, PN 16	10K	156	6.14	–	–	–	–
300	12	PN 10	Class 150	Table E, PN 16	10K	309	12.2	309	12.2	306	12.05
300 [1]	12	PN 16	Class 150	Table E, PN 16	10K	204	8.03	–	–	–	–
350	14	PN 6	Class 150	Table E, PN 16	10K	337	13.3	342	13.5	–	–
375	15	–	–	PN 16	10K	389	15.3	–	–	–	–
400	16	PN 6	Class 150	Table E, PN 16	10K	387	15.2	392	15.4	–	–
450	18	PN 6	Class 150	–	10K	436	17.1	437	17.2	–	–
500	20	PN 6	Class 150	Table E, PN 16	10K	487	19.1	492	19.4	–	–
600	24	PN 6	Class 150	Table E, PN 16	10K	589	23.0	594	23.4	–	–
700	28	PN 6	Class D	Table E, PN 16	10K	688	27.1	692	27.2	–	–
750	30	–	Class D	Table E, PN 16	10K	737	29.1	742	29.2	–	–
800	32	PN 6	Class D	Table E, PN 16	–	788	31.0	794	31.3	–	–
900	36	PN 6	Class D	Table E, PN 16	–	889	35.0	891	35.1	–	–
1000	40	PN 6	Class D	Table E, PN 16	–	991	39.0	994	39.1	–	–
–	42	–	Class D	–	–	1043	41.1	1043	41.1	–	–
1200	48	PN 6	Class D	Table E, PN 16	–	1191	46.9	1197	47.1	–	–
–	54	–	Class D	–	–	1339	52.7	–	–	–	–
1400	–	PN 6	–	–	–	1402	55.2	–	–	–	–
–	60	–	Class D	–	–	1492	58.7	–	–	–	–
1600	–	PN 6	–	–	–	1600	63.0	–	–	–	–
–	66	–	Class D	–	–	1638	64.5	–	–	–	–
1800	72	PN 6	–	–	–	1786	70.3	–	–	–	–
–	78	–	Class D	–	–	1989	78.3	–	–	–	–
2000	–	PN 6	–	–	–	1989	78.3	–	–	–	–
–	84	–	Class D	–	–	2099	84.0	–	–	–	–
2200	–	PN 6	–	–	–	2194	87.8	–	–	–	–

Nominal diameter		Pressure rating				Measuring tube internal diameter					
		EN (DIN)	ASME AWWA	AS 2129 AS 4087	JIS	Hard rubber		Polyurethane		PTFE	
[mm]	[in]					[mm]	[in]	[mm]	[in]	[mm]	[in]
–	90	–	Class D	–	–	2246	89.8	–	–	–	–
2400	–	PN 6	–	–	–	2391	94.1	–	–	–	–

1) Order code for "Design", option C

Materials

Transmitter housing

Compact version

- Order code for "Housing", option **A** "Compact, alu, coated": Aluminum, AlSi10Mg, coated
- Order code for "Housing", option **M**: polycarbonate plastic
- Window material:
  - For order code for "Housing", option **A**: glass
  - For order code for "Housing", option **M**: plastic

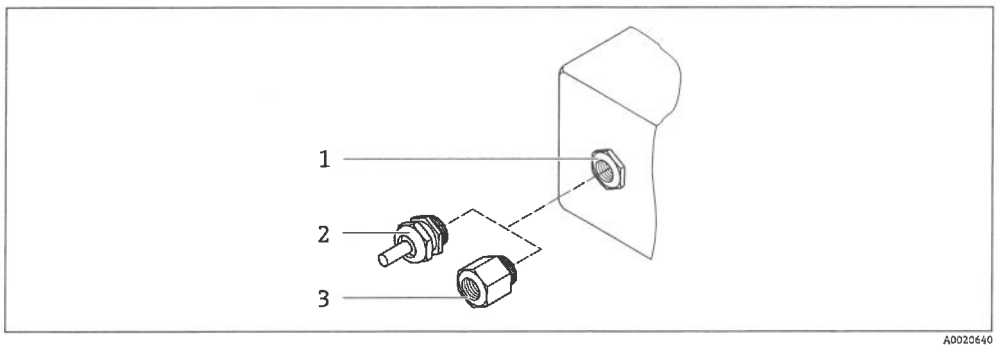
Remote version (wall-mount housing)

- Order code for "Housing", option **P** "Remote, alu, coated": Aluminum, AlSi10Mg, coated
- Order code for "Housing", option **N**: polycarbonate plastic
- Window material:
  - For order code for "Housing", option **P**: glass
  - For order code for "Housing", option **N**: plastic

Sensor connection housing

- Aluminum, AlSi10Mg, coated
- Polycarbonate plastic (only in conjunction with order code for "Sensor option", options CA...CE)

Cable entries/cable glands



36 *Possible cable entries/cable glands*

1 *Female thread M20 × 1.5*
2 *Cable gland M20 × 1.5*
3 *Adapter for cable entry with internal thread G ½" or NPT ½"*

Compact and remote versions and sensor connection housing

Cable entry/cable gland	Material
Cable gland M20 × 1.5	Plastic
Remote version: cable gland M20 × 1.5 Option of reinforced connecting cable	▪ Sensor connection housing: Nickel-plated brass ▪ Transmitter wall-mount housing: Plastic
Adapter for cable entry with internal thread G ½" or NPT ½"	Nickel-plated brass

Device plug

Electrical connection	Material
Plug M12x1	▪ Socket: Stainless steel, 1.4404 (316L) ▪ Contact housing: Polyamide ▪ Contacts: Gold-plated brass

Connecting cable for remote version

Electrode and coil current cable
- Standard cable: PVC cable with copper shield
- Reinforced cable: PVC cable with copper shield and additional steel wire braided jacket

Sensor housing

- DN 25 to 300 (1 to 12")
  - Aluminum half-shell housing, aluminum, AlSi10Mg, coated
  - Fully welded carbon steel housing with protective varnish
- DN 350 to 2400 (14 to 90")
  Fully welded carbon steel housing with protective varnish

Measuring tubes

- DN 25 to 600 (1 to 24")
  Stainless steel: 1.4301, 1.4306, 304, 304L
- DN 700 to 2400 (28 to 90")
  Stainless steel: 1.4301, 304

Liner

- DN 25 to 300 (1 to 12"): PTFE
- DN 25 to 1200 (1 to 48"): polyurethane
- DN 50 to 2400 (2 to 90"): hard rubber

Electrodes

- Stainless steel, 1.4435 (316L)
- Alloy C22, 2.4602 (UNS N06022)
- Tantalum

Process connections

For flanges made of carbon steel:
- DN ≤ 300 (12"): with Al/Zn protective coating or protective varnish
- DN ≥ 350 (14"): protective varnish

All carbon steel lap joint flanges are supplied with a hot-dip galvanized finish.

EN 1092-1 (DIN 2501)

Fixed flange
- Carbon steel:
  - DN ≤ 300: S235JRG2, S235JR+N, P245GH, A105, E250C
  - DN 350 to 2400: P245GH, S235JRG2, A105, E250C
- Stainless steel:
  - DN ≤ 300: 1.4404, 1.4571, F316L
  - DN 350 to 600: 1.4571, F316L, 1.4404
  - DN 700 to 1000: 1.4404, F316L

Lap joint flange
- Carbon steel DN ≤ 300: S235JRG2, A105, E250C
- Stainless steel DN ≤ 300: 1.4306,1.4404, 1.4571, F316L

Lap joint flange, stamped plate
- Carbon steel DN ≤ 300: S235JRG2 similar to S235JR+AR or 1.0038
- Stainless steel DN ≤ 300: 1.4301 similar to 304

ASME B16.5

Fixed flange, lap joint flange
- Carbon steel: A105
- Stainless steel: F316L

JIS B2220

- Carbon steel: A105, A350 LF2
- Stainless steel: F316L

AWWA C207

Carbon steel: A105, P265GH, A181 Class 70, E250C, S275JR

AS 2129

Carbon steel: A105, E250C, P235GH, P265GH, S235JRG2

AS 4087

Carbon steel: A105, P265GH, S275JR

Seals

As per DIN EN 1514-1, form IBC

Accessories

Display guard

Stainless steel, 1.4301 (304L)

Ground disks

- Stainless steel, 1.4435 (316L)
- Alloy C22, 2.4602 (UNS N06022)
- Tantalum

Fitted electrodes

Measurement, reference and empty pipe detection electrodes available as standard with:
- 1.4435 (316L)
- Alloy C22, 2.4602 (UNS N06022)
- Tantalum

Process connections

- EN 1092-1 (DIN 2501)
  - DN ≤ 300: fixed flange (PN 10/16/25/40) = Form A, lap joint flange (PN 10/16), lap joint flange, stamped plate (PN 10) = Form A
  - DN ≥ 350: fixed flange (PN 6/10/16/25) = flat face (Form B)
  - DN 450 to 2400: fixed flange (PN 6/10/16) = flat face (Form B)
- ASME B16.5
  - DN 350 to 2400 (14 to 90"): fixed flange (Class 150)
  - DN 25 to 600 (1 to 24"): lap joint flange (Class 150)
  - DN 25 to 150 (1 to 6"): fixed flange (Class 300)
- JIS B2220
  - DN 50 to 750: fixed flange (10K)
  - DN 25 to 600: fixed flange (20K)
- AWWA C207
  DN 48 to 90": fixed flange (Class D)
- AS 2129
  DN 50 to 1200: fixed flange (Table E)
- AS 4087
  DN 50 to 1200): fixed flange (PN 16)

For information on the different materials used in the process connections → 84

Surface roughness

Electrodes with 1.4435 (316L); Alloy C22, 2.4602 (UNS N06022); tantalum:
≤ 0.3 to 0.5 µm (11.8 to 19.7 µin)
(All data relate to parts in contact with fluid)

Human interface

Operating concept

Operator-oriented menu structure for user-specific tasks
- Commissioning
- Operation
- Diagnostics
- Expert level

Fast and safe commissioning
- Guided menus ("Make-it-run" wizards) for applications
- Menu guidance with brief descriptions of the individual parameter functions
- Access to the device via Web server or SmartBlue App → 97
- WLAN access to the device via mobile handheld terminal, tablet or smart phone

Reliable operation
- Operation in local language
- Uniform operating philosophy applied to device and operating tools
- If replacing electronic modules, transfer the device configuration via the integrated memory (HistoROM backup) which contains the process and measuring device data and the event logbook. No need to reconfigure.

Efficient diagnostics increase measurement availability
- Troubleshooting measures can be called up via the device and in the operating tools
- Diverse simulation options, logbook for events that occur and optional line recorder functions

Languages

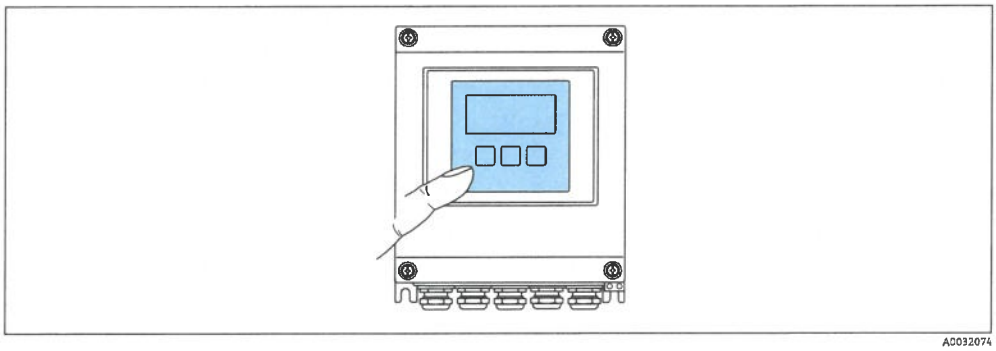
Can be operated in the following languages:
- Via local operation:
  English, German, French, Spanish, Italian, Dutch, Portuguese, Polish, Russian, Turkish, Chinese, Japanese, Bahasa (Indonesian), Vietnamese, Czech, Swedish
- Via "FieldCare", "DeviceCare" operating tool:
  English, German, French, Spanish, Italian, Chinese, Japanese
- Via Web browser (only available for device versions with HART, PROFIBUS DP and EtherNet/IP):
  English, German, French, Spanish, Italian, Dutch, Portuguese, Polish, Russian, Turkish, Chinese, Japanese, Bahasa (Indonesian), Vietnamese, Czech, Swedish

Local display

Via display module

Features:
- Standard features 4-line, illuminated, graphic display; touch control
- Order code for "Display; operation", option BA "WLAN" = standard features plus access via Web browser

Information about WLAN interface → 89



37 *Operation with touch control*

Display elements

- 4-line, illuminated, graphic display
- White background lighting; switches to red in event of device errors
- Format for displaying measured variables and status variables can be individually configured
- Permitted ambient temperature for the display: –20 to +60 °C (–4 to +140 °F)
  The readability of the display may be impaired at temperatures outside the temperature range.

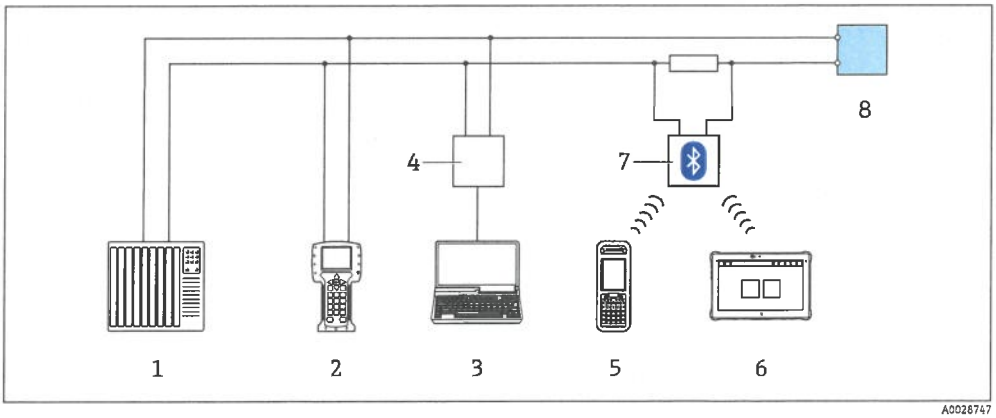
Operating elements

- External operation via touch control (3 optical keys) without opening the housing: ⊞, ⊟, Ⓔ
- Operating elements also accessible in the various zones of the hazardous area

Remote operation

Via HART protocol

This communication interface is available in device versions with a HART output.

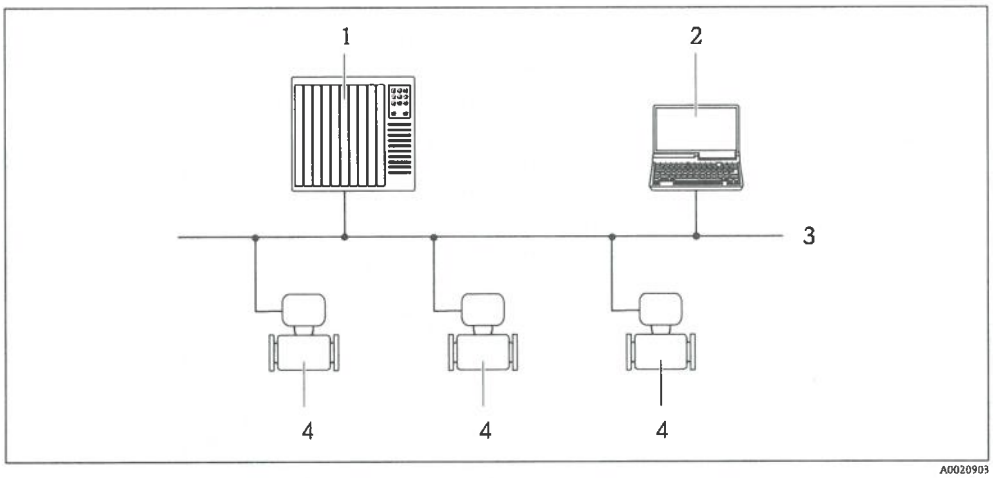


38 *Options for remote operation via HART protocol*

1 *Control system (e.g. PLC)*
2 *Field Communicator 475*
3 *Computer with operating tool (e.g. FieldCare, AMS Device Manager, SIMATIC PDM)*
4 *Commubox FXA195 (USB)*
5 *Field Xpert SFX350 or SFX370*
6 *Field Xpert SMT70*
7 *VIATOR Bluetooth modem with connecting cable*
8 *Transmitter*

Via PROFIBUS DP network

This communication interface is available in device versions with PROFIBUS DP.

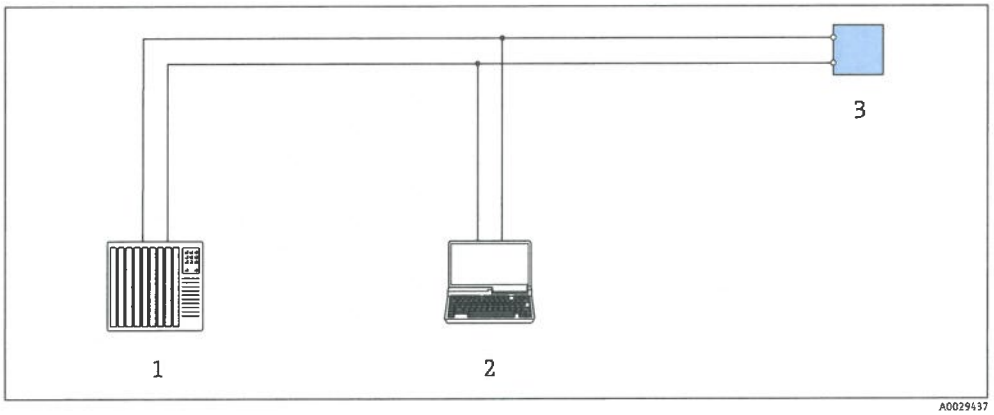


39 *Options for remote operation via PROFIBUS DP network*

1 *Automation system*
2 *Computer with PROFIBUS network card*
3 *PROFIBUS DP network*
4 *Measuring device*

Via Modbus RS485 protocol

This communication interface is available in device versions with a Modbus-RS485 output.



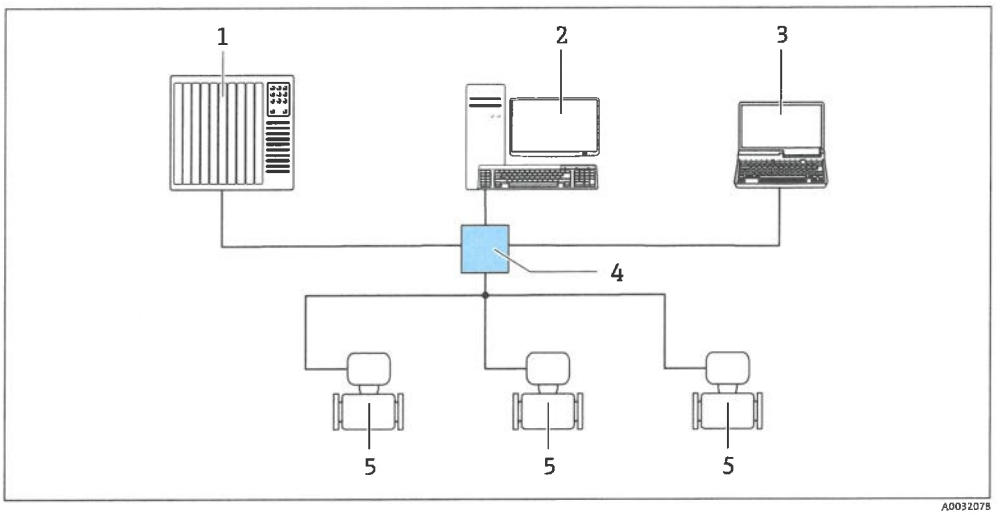
40 *Options for remote operation via Modbus-RS485 protocol (active)*

1 *Control system (e.g. PLC)*
2 *Computer with Web browser (e.g. Internet Explorer) for accessing the integrated device Web server or with operating tool (e.g. FieldCare, DeviceCare) with COM DTM "CDI Communication TCP/IP" or Modbus DTM*
3 *Transmitter*

Via EtherNet/IP network

This communication interface is available in device versions with EtherNet/IP.

Star topology



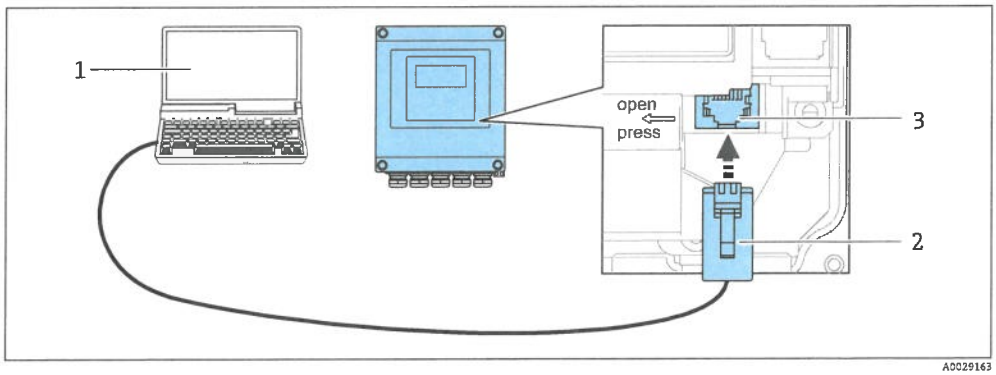
41 *Options for remote operation via EtherNet/IP network: star topology*

1 *Automation system, e.g. "RSLogix" (Rockwell Automation)*
2 *Workstation for measuring device operation: with Custom Add-On Profile for "RSLogix 5000" (Rockwell Automation) or with Electronic Data Sheet (EDS)*
3 *Computer with Web browser (e.g. Internet Explorer) for accessing the integrated device Web server or computer with operating tool (e.g. FieldCare, DeviceCare) with COM DTM "CDI Communication TCP/IP"*
4 *Ethernet switch*
5 *Measuring device*

Service interface

Via service interface (CDI-RJ45)

This communication interface is present in the following device version:
- Order code for "Output", option **H**: 4-20/0-20 mA HART, pulse/frequency/switch output
- Order code for "Output", option **I**: 4-20/0-20 mA HART, pulse/frequency/switch output, status input
- Order code for "Output", option **L**: PROFIBUS DP
- Order code for "Output", option **N**: EtherNet/IP
- Order code for "Output", option **M**: Modbus RS485

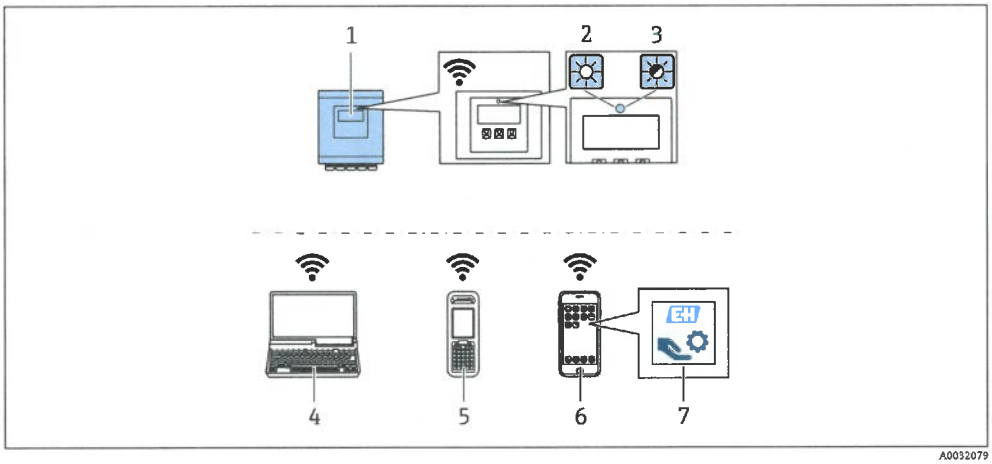


42 *Connection via service interface (CDI-RJ45)*

1 *Computer with Web browser (e.g. Microsoft Internet Explorer, Microsoft Edge) for accessing the integrated device Web server or with "FieldCare", "DeviceCare" operating tool with COM DTM "CDI Communication TCP/IP" or Modbus DTM*
2 *Standard Ethernet connecting cable with RJ45 plug*
3 *Service interface (CDI-RJ45) of the measuring device with access to the integrated Web server*

Via WLAN interface

The optional WLAN interface is available on the following device version:
Order code for "Display", option BA "WLAN":
4-line, illuminated, graphic display; touch control + WLAN



1 *Transmitter with integrated WLAN antenna*
2 *LED lit constantly: WLAN reception is enabled on measuring device*
3 *LED flashing: WLAN connection established between operating unit and measuring device*
4 *Computer with WLAN interface and Web browser (e.g. Microsoft Internet Explorer, Microsoft Edge) for accessing the integrated device Web server or with operating tool (e.g. FieldCare, DeviceCare)*
5 *Mobile handheld terminal with WLAN interface and Web browser (e.g. Microsoft Internet Explorer, Microsoft Edge) for accessing the integrated device Web server or operating tool (e.g. FieldCare, DeviceCare)*
6 *Smart phone or tablet (e.g. Field Xpert SMT70)*
7 *SmartBlue App*

Function	WLAN: IEEE 802.11 b/g (2.4 GHz) ▪ Access point with DHCP server (default setting) ▪ Network
Encryption	WPA2-PSK AES-128 (in accordance with IEEE 802.11i)
Configurable WLAN channels	1 to 11
Degree of protection	IP67
Available antennas	▪ Internal antenna ▪ External antenna (optional) In the event of poor transmission/reception conditions at the place of installation. Available as an accessory . Only one antenna active in each case!
Range	▪ Internal antenna: typically 10 m (32 ft) ▪ External antenna: typically 50 m (164 ft)
Materials (external antenna)	▪ Antenna: ASA plastic (acrylic ester-styrene-acrylonitrile) and nickel-plated brass ▪ Adapter: Stainless steel and nickel-plated brass ▪ Cable: Polyethylene ▪ Connector: Nickel-plated brass ▪ Angle bracket: Stainless steel

Supported operating tools

Different operating tools can be used for local or remote access to the measuring device. Depending on the operating tool used, access is possible with different operating units and via a variety of interfaces.

Supported operating tools	Operating unit	Interface	Additional information
Web browser	Notebook, PC or tablet with Web browser	▪ CDI-RJ45 service interface ▪ WLAN interface ▪ Ethernet-based fieldbus (EtherNet/IP)	Special Documentation for device
DeviceCare SFE100	Notebook, PC or tablet with Microsoft Windows system	▪ CDI-RJ45 service interface ▪ WLAN interface ▪ Fieldbus protocol	→ 🖹 97
FieldCare SFE500	Notebook, PC or tablet with Microsoft Windows system	▪ CDI-RJ45 service interface ▪ WLAN interface ▪ Fieldbus protocol	→ 🖹 97
Device Xpert	Field Xpert SFX 100/350/370	HART and FOUNDATION Fieldbus fieldbus protocol	Operating Instructions BA01202S Device description files: Use update function of handheld terminal

Other operating tools based on FDT technology with a device driver such as DTM/iDTM or DD/EDD can be used for device operation. These operating tools are available from the individual manufacturers. Integration into the following operating tools, among others, is supported:

- FactoryTalk AssetCentre (FTAC) by Rockwell Automation → www.rockwellautomation.com
- Process Device Manager (PDM) by Siemens → www.siemens.com
- Asset Management Solutions (AMS) by Emerson → www.emersonprocess.com
- FieldCommunicator 375/475 by Emerson → www.emersonprocess.com
- Field Device Manager (FDM) by Honeywell → www.honeywellprocess.com
- FieldMate by Yokogawa → www.yokogawa.com
- PACTWare → www.pactware.com

The associated device description files are available at: www.endress.com → Downloads

Web server

Thanks to the integrated Web server, the device can be operated and configured via a Web browser and via a service interface (CDI-RJ45) or via a WLAN interface. The structure of the operating menu is the same as for the local display. In addition to the measured values, status information on the device is also displayed and allows the user to monitor the status of the device. Furthermore the device data can be managed and the network parameters can be configured.

A device that has a WLAN interface (can be ordered as an option) is required for the WLAN connection: order code for "Display", option BA "WLAN": 4-line, illuminated; touch control + WLAN. The device acts as an Access Point and enables communication by computer or a mobile handheld terminal.

Supported functions
Data exchange between the operating unit (such as a notebook for example) and the measuring device:
- Upload the configuration from the measuring device (XML format, configuration backup)
- Save the configuration to the measuring device (XML format, restore configuration)
- Export event list (.csv file)
- Export parameter settings (.csv file or PDF file, document the measuring point configuration)
- Export the Heartbeat verification log (PDF file, only available with the "Heartbeat Verification" application package)
- Flash firmware version for device firmware upgrade, for instance
- Download driver for system integration
- Visualize up to 1000 saved measured values (only available with the **Extended HistoROM** application package → 🖹 95)

Web server special documentation → 🖹 98

HistoROM data management

The measuring device features HistoROM data management. HistoROM data management comprises both the storage and import/export of key device and process data, making operation and servicing far more reliable, secure and efficient.

Additional information on the data storage concept

There are different types of data storage units in which device data are stored and used by the device:

	Device memory	T-DAT	S-DAT
Available data	▪ Device firmware package ▪ Driver for system integration e.g.: ▪ GSD for PROFIBUS DP ▪ EDS for EtherNet/IP	▪ Event history, such as diagnostic events ▪ Measured value memory ("Extended HistoROM" order option) ▪ Current parameter data record (used by firmware at run time) ▪ Maximum indicators (min/max values) ▪ Totalizer values	▪ Sensor data: diameter etc. ▪ Serial number ▪ User-specific access code (to use the "Maintenance" user role) ▪ Calibration data ▪ Device configuration (e.g. SW options, fixed I/O or multi I/O)
Storage location	Fixed on the user interface board in the connection compartment	Can be plugged into the user interface board in the connection compartment	In the sensor plug in the transmitter neck part

Data backup

Automatic

- The most important device data (sensor and transmitter) are automatically saved in the DAT modules
- If the transmitter or measuring device is replaced: once the T-DAT containing the previous device data has been exchanged, the new measuring device is ready for operation again immediately without any errors
- If the sensor is replaced: once the sensor has been replaced, new sensor data are transferred from the S-DAT in the measuring device and the measuring device is ready for operation again immediately without any errors

Data transfer

Manual

- Transfer of a device configuration to another device using the export function of the specific operating tool, e.g. with FieldCare, DeviceCare or Web server: to duplicate the configuration or to store in an archive (e.g. for backup purposes)
- Transmission of the drivers for system integration via Web server, e.g.:
  - GSD for PROFIBUS DP
  - EDS for EtherNet/IP

Event list

Automatic

- Chronological display of up to 20 event messages in the events list
- If the **Extended HistoROM** application package (order option) is enabled: up to 100 event messages are displayed in the events list along with a time stamp, plain text description and remedial measures
- The events list can be exported and displayed via a variety of interfaces and operating tools e.g. DeviceCare, FieldCare or Web server

Data logging

Manual

If the **Extended HistoROM** application package (order option) is enabled:

- Record up to 1 000 measured values via 1 to 4 channels
- User configurable recording interval
- Record up to 250 measured values via each of the 4 memory channels
- Export the measured value log via a variety of interfaces and operating tools e.g. FieldCare, DeviceCare or web server

Certificates and approvals

Currently available certificates and approvals can be called up via the product configurator.

CE mark

The device meets the legal requirements of the applicable EU Directives. These are listed in the corresponding EU Declaration of Conformity along with the standards applied.

Endress+Hauser confirms successful testing of the device by affixing to it the CE mark.

RCM-tick symbol

The measuring system meets the EMC requirements of the "Australian Communications and Media Authority (ACMA)".

Ex approval

The devices are certified for use in hazardous areas and the relevant safety instructions are provided in the separate "Control Drawing" document. Reference is made to this document on the nameplate.

Drinking water approval

- ACS
- KTW/W270
- NSF 61
- WRAS BS 6920

HART certification

HART interface

The measuring device is certified and registered by the FieldComm Group. The measuring system meets all the requirements of the following specifications:
- Certified according to HART 7
- The device can also be operated with certified devices of other manufacturers (interoperability)

Certification PROFIBUS

PROFIBUS interface

The measuring device is certified and registered by the PNO (PROFIBUS User Organization Organization). The measuring system meets all the requirements of the following specifications:
- Certified in accordance with PROFIBUS PA Profile 3.02
- The device can also be operated with certified devices of other manufacturers (interoperability)

Modbus RS485 certification

The measuring device meets all the requirements of the MODBUS/TCP conformity test and has the "MODBUS/TCP Conformance Test Policy, Version 2.0". The measuring device has successfully passed all the test procedures carried out.

EtherNet/IP certification

The measuring device is certified and registered by the ODVA (Open Device Vendor Association). The measuring system meets all the requirements of the following specifications:
- Certified in accordance with the ODVA Conformance Test
- EtherNet/IP Performance Test
- EtherNet/IP PlugFest compliance
- The device can also be operated with certified devices of other manufacturers (interoperability)

Radio approval

The measuring device has radio approval.

For detailed information regarding radio approval, see Special Documentation → 98

Measuring instrument approval

The measuring device is (optionally) approved as a cold water meter (MI-001) for volume measurement in service subject to legal metrological control in accordance with the European Measuring Instruments Directive 2014/32/EU (MID).

The measuring device is qualified to OIML R49: 2013.

Other standards and guidelines

- EN 60529
  Degrees of protection provided by enclosures (IP code)
- EN 61010-1
  Safety requirements for electrical equipment for measurement, control and laboratory use - general requirements
- IEC/EN 61326
  Emission in accordance with Class A requirements. Electromagnetic compatibility (EMC requirements).

- ANSI/ISA-61010-1 (82.02.01)
  Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use - Part 1 General Requirements
- CAN/CSA-C22.2 No. 61010-1-12
  Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use - Part 1 General Requirements
- NAMUR NE 21
  Electromagnetic compatibility (EMC) of industrial process and laboratory control equipment
- NAMUR NE 32
  Data retention in the event of a power failure in field and control instruments with microprocessors
- NAMUR NE 43
  Standardization of the signal level for the breakdown information of digital transmitters with analog output signal.
- NAMUR NE 53
  Software of field devices and signal-processing devices with digital electronics
- NAMUR NE 105
  Specifications for integrating fieldbus devices in engineering tools for field devices
- NAMUR NE 107
  Self-monitoring and diagnosis of field devices
- NAMUR NE 131
  Requirements for field devices for standard applications

Ordering information

Detailed ordering information is available from the following sources:
- In the Product Configurator on the Endress+Hauser website: www.endress.com -> Click "Corporate" -> Select your country -> Click "Products" -> Select the product using the filters and search field -> Open product page -> The "Configure" button to the right of the product image opens the Product Configurator.
- From your Endress+Hauser Sales Center: www.addresses.endress.com

Product Configurator - the tool for individual product configuration
- Up-to-the-minute configuration data
- Depending on the device: Direct input of measuring point-specific information such as measuring range or operating language
- Automatic verification of exclusion criteria
- Automatic creation of the order code and its breakdown in PDF or Excel output format
- Ability to order directly in the Endress+Hauser Online Shop

Product generation index

Release date	Product root	Modification
01.07.2012	5W4B	Original
01.11.2016	5W4C	▪ Web server: current version ▪ Logbook: current concept, including Parameter Change ▪ Upload/download: current concept ▪ Heartbeat Technology: new hardware, diagnostics, events ▪ Security concept: encrypted password transmission ▪ WLAN ▪ Custody transfer mode

More information is available from your Sales Center or at:
www.service.endress.com → Downloads

Application packages

Many different application packages are available to enhance the functionality of the device. Such packages might be needed to address safety aspects or specific application requirements.

The application packages can be ordered with the device or subsequently from Endress+Hauser. Detailed information on the order code in question is available from your local Endress+Hauser sales center or on the product page of the Endress+Hauser website: www.endress.com.

Cleaning

Package	Description
Electrode cleaning circuit (ECC)	The electrode cleaning circuit (ECC) function has been developed to have a solution for applications where magnetite (Fe_3O_4) deposits frequently occur (e.g. hot water). Since magnetite is highly conductive this build up leads to measuring errors and ultimately to the loss of signal. The application package is designed to AVOID build up of highly conductive matter and thin layers (typical of magnetite).

Diagnostics functions

Package	Description
Extended HistoROM	Comprises extended functions concerning the event log and the activation of the measured value memory. Event log: Memory volume is extended from 20 message entries (standard version) to up to 100 entries. Data logging (line recorder): ▪ Memory capacity for up to 1000 measured values is activated. ▪ 250 measured values can be output via each of the 4 memory channels. The recording interval can be defined and configured by the user. ▪ Measured value logs can be accessed via the local display or operating tool e.g. FieldCare, DeviceCare or Web server.

Heartbeat Technology

Package	Description
Heartbeat Verification +Monitoring	**Heartbeat Verification** Meets the requirement for traceable verification to DIN ISO 9001:2008 Chapter 7.6 a) "Control of monitoring and measuring equipment". ▪ Functional testing in the installed state without interrupting the process. ▪ Traceable verification results on request, including a report. ▪ Simple testing process via local operation or other operating interfaces. ▪ Clear measuring point assessment (pass/fail) with high test coverage within the framework of manufacturer specifications. ▪ Extension of calibration intervals according to operator's risk assessment. **Heartbeat Monitoring** Continuously supplies data, which are characteristic of the measuring principle, to an external condition monitoring system for the purpose of preventive maintenance or process analysis. These data enable the operator to: ▪ Draw conclusions - using these data and other information - about the impact process influences (such as corrosion, abrasion, buildup etc.) have on the measuring performance over time. ▪ Schedule servicing in time. ▪ Monitor the process or product quality, e.g. gas pockets.

Accessories

Various accessories, which can be ordered with the device or subsequently from Endress+Hauser, are available for the device. Detailed information on the order code in question is available from your local Endress+Hauser sales center or on the product page of the Endress+Hauser website: www.endress.com.

Device-specific accessories

For the transmitter

Accessories	Description
Promag 400 transmitter	Transmitter for replacement or storage. Use the order code to define the following specifications: ▪ Approvals ▪ Output / input ▪ Display/operation ▪ Housing ▪ Software For details, see Installation Instructions EA00104D
Display guard	Is used to protect the display against impact or scoring from sand in desert areas. Order number: 71228792 Installation Instructions EA01093D
Connecting cable for remote version	Coil current and electrode cables, various lengths, reinforced cables available on request.
Ground cable	Set, consisting of two ground cables for potential equalization.
Post mounting kit	Post mounting kit for transmitter.
Compact → Remote conversion kit	For converting a compact device version to a remote device version.
Conversion kit Promag 50/53 → Promag 400	For converting a Promag with transmitter 50/53 to a Promag 400.

For the sensor

Accessories	Description
Ground disks	Are used to ground the medium in lined measuring tubes to ensure proper measurement. For details, see Installation Instructions EA00070D

Communication-specific accessories

Accessories	Description
Commubox FXA195 HART	For intrinsically safe HART communication with FieldCare via the USB interface. Technical Information TI00404F
Commubox FXA291	Connects Endress+Hauser field devices with a CDI interface (= Endress+Hauser Common Data Interface) and the USB port of a computer or laptop. Technical Information TI405C/07
HART Loop Converter HMX50	Is used to evaluate and convert dynamic HART process variables to analog current signals or limit values. ▪ Technical Information TI00429F ▪ Operating Instructions BA00371F
Wireless HART adapter SWA70	Is used for the wireless connection of field devices. The WirelessHART adapter can be easily integrated into field devices and existing infrastructures, offers data protection and transmission safety and can be operated in parallel with other wireless networks with minimum cabling complexity. Operating Instructions BA00061S
Fieldgate FXA42	Is used to transmit the measured values of connected 4 to 20 mA analog measuring devices, as well as digital measuring devices ▪ Technical Information TI01297S ▪ Operating Instructions BA01778S ▪ Product page: www.endress.com/fxa42

Field Xpert SMT70	The Field Xpert SMT70 tablet PC for device configuration enables mobile plant asset management in hazardous and non-hazardous areas. It is suitable for commissioning and maintenance staff to manage field instruments with a digital communication interface and to record progress. This tablet PC is designed as an all-in-one solution with a preinstalled driver library and is an easy-to-use, touch-sensitive tool which can be used to manage field instruments throughout their entire life cycle. ▪ Technical Information TI01342S ▪ Operating Instructions BA01709S ▪ Product page: www.endress.com/smt70
Field Xpert SMT77	The Field Xpert SMT77 tablet PC for device configuration enables mobile plant asset management in areas categorized as Ex Zone 1. ▪ Technical Information TI01418S ▪ Operating Instructions BA01923S ▪ Product page: www.endress.com/smt77

Service-specific accessories

Accessories	Description
Applicator	Software for selecting and sizing Endress+Hauser measuring devices: ▪ Choice of measuring devices for industrial requirements ▪ Calculation of all the necessary data for identifying the optimum flowmeter: e.g. nominal diameter, pressure loss, flow velocity and accuracy. ▪ Graphic illustration of the calculation results ▪ Determination of the partial order code, administration, documentation and access to all project-related data and parameters over the entire life cycle of a project. Applicator is available: ▪ Via the Internet: https://portal.endress.com/webapp/applicator ▪ As a downloadable DVD for local PC installation.
W@M	W@M Life Cycle Management Improved productivity with information at your fingertips. Data relevant to a plant and its components is generated from the first stages of planning and during the asset's complete life cycle. W@M Life Cycle Management is an open and flexible information platform with online and on-site tools. Instant access for your staff to current, in-depth data shortens your plant's engineering time, speeds up procurement processes and increases plant uptime. Combined with the right services, W@M Life Cycle Management boosts productivity in every phase. For more information, visit www.endress.com/lifecyclemanagement
FieldCare	FDT-based plant asset management tool from Endress+Hauser. It can configure all smart field units in your system and helps you manage them. By using the status information, it is also a simple but effective way of checking their status and condition. Operating Instructions BA00027S and BA00059S
DeviceCare	Tool to connect and configure Endress+Hauser field devices. Innovation brochure IN01047S
Commubox FXA291	Connects Endress+Hauser field devices with a CDI interface (= Endress +Hauser Common Data Interface) and the USB port of a computer or laptop. Technical Information TI00405C

System components

Accessories	Description
Memograph M graphic data manager	The Memograph M graphic data manager provides information on all the relevant measured variables. Measured values are recorded correctly, limit values are monitored and measuring points analyzed. The data are stored in the 256 MB internal memory and also on a SD card or USB stick. ▪ Technical Information TI00133R ▪ Operating Instructions BA00247R

Supplementary documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- *W@M Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2D matrix code (QR code) on the nameplate

Standard documentation

Brief Operating Instructions

Brief Operating Instructions for the sensor

Measuring device	Documentation code
Proline Promag W	KA01266D

Transmitter Brief Operating Instructions

Measuring device	Documentation code			
	HART	PROFIBUS DP	Modbus RS485	EtherNet/IP
Proline 400	KA01263D	KA01420D	KA01419D	KA01418D

Operating Instructions

Measuring device	Documentation code			
	HART	PROFIBUS DP	Modbus RS485	EtherNet/IP
Promag W 400	BA01063D	BA01234D	BA01231D	BA01214D

Description of device parameters

Measuring device	Documentation code			
	HART	PROFIBUS DP	Modbus RS485	EtherNet/IP
Promag 400	GP01043D	GP01044D	GP01045D	GP01046D

Supplementary device-dependent documentation

Special Documentation

Content	Documentation code
Heartbeat Technology	SD01847D
Display modules A309/A310	SD01793D
Information on Custody Transfer Measurement	SD02038D

Content	Documentation code			
	HART	PROFIBUS DP	Modbus RS485	EtherNet/IP
Web server	SD01811D	SD01813D	SD01812D	SD01814D

Installation Instructions

Content	Comment
Installation instructions for spare part sets and accessories	Documentation code: specified for each individual accessory → 96.

Registered trademarks

HART®
Registered trademark of the FieldComm Group, Austin, Texas, USA

PROFIBUS®
Registered trademark of the PROFIBUS User Organization, Karlsruhe, Germany

Modbus®
Registered trademark of SCHNEIDER AUTOMATION, INC.

EtherNet/IP™
Trademark of ODVA, Inc.

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b. The verification technique shall not require external handhelds, interfaces, special tooling or electrical access for a verification to be performed.

c. A verification of the system shall be possible at any time, locally or remotely, on demand and under process conditions.

d. The verification report shall be compliant to common quality systems such as ISO 9000 to prove reliability of the meter specified accuracy.

11. The transmitter display shall have a sunshade to enable viewing in strong or direct sunlight.

T. Accessories

1. Stainless steel tag shall be provided and affixed as identified in the data sheets.

2. Provide grounding rings, as per manufacturer's recommendations.

3. Provide a sun shield for outdoor installation of transmitter.

U. Source Quality Control and Calibration

1. Magnetic flow meters shall be factory calibrated on an ISO 17025 accredited test stand per "General Requirements for the Competence of Testing and Calibration Laboratories" with certified accuracy traceable to NIST.

2. Evidence of accreditation shall originate from a national verification agency such as A2LA.

3. Each meter shall ship with a certificate of a 5-point calibration report meeting or exceeding stated standard accuracy of 0.5 percent of flowrate.

a. Optional calibration to 0.2 percent of rate shall be performed.

b. An optional performance calibration for a Flat Accuracy Specification shall be performed in the event of low initial design flow rate.

4. A real-time computer-generated printout of the actual calibration data points shall indicate apparent and actual flows. The flow calibration data shall be confirmed by the manufacturer and shipped with the meters to the project site.

5. The manufacturer shall provide complete documentation covering the traceability of all calibration instruments.

6. The manufacturer shall update data sheets as shown in the Appendix of this specification with all known data and model codes and dash out the

inapplicable fields with the Bid. Incomplete data sheets submitted will result in a rejected bid. Fields left unchanged will be assumed to not require changes and the Supplier is in accordance.

V. Safety

1. All electrical equipment shall meet the requirements of ANSI/NFPA 70, National Electric Code latest edition.

2. Electrical equipment housing shall conform to electrical classifications as identified in the data sheets.

3. Non-intrinsically safe electrical equipment shall be approved by a Nationally Recognized Testing Laboratory (NRTL, such as FM, UL, or CSA) for the specified electrical area classification.

2.05 RADAR LEVEL METERS

A. The radar transmitter shall be 24 VDC loop powered, operate at 26 GHz or greater using 2 wire technology for level measurement and provide a 4 20 mA output. HART, Profibus PA and Foundation Fieldbus will also be available if required.

B. The transmitter housing shall be available in plastic, die cast aluminum with a powder Epoxy coating or 316L Stainless steel based on the application environment. Housing shall be rated IP66/67 and or NEMA 4/4X

C. Unit shall be suitable for the electrical area classification as required and as identified in the data sheets.

D. Unit shall employ multi echo tracking algorithms for reliable level measurement. The beam angle for the antenna shall be 10 degrees or greater; outside this beam angle the energy level of the radar signal shall not deteriorate by greater than 50 percent.

E. The unit shall not be affected by changing media, changing temperatures, gas blankets, presence of dust, or vapors. The transmitter shall measure almost completely independent from product properties.

F. The transmitter will have a glare resistant LCD display, which can be remote mounted if required. All programming and set-up can be done on the display, or via separate software. The unit will have the capability of mapping out any object that causes an interference the in the radar reflections.

G. Software shall be provided for optional remote method of configuration, set-up and storage of parameters via a computer.

H. The display module shall be capable of data backup, data comparison and data transfer functions.