2017

PRODUCT LINE CATALOGUE

Magnetrol®

Worldwide Level and Flow Solutions℠

VISION STATEMENT

To be the customers' preferred partner
in the global supply of level and flow control solutions

COMPANY

"Industry leader" is a role Magnetrol® has played for over 85 years. In fact, the history of MAGNETROL is a story of the pioneers who built the level instrumentation industry.

We manufactured the first liquid level switch to accurately and safely detect motion of liquid in boilers and feedwater systems and we also introduced the first pneumatic valve controller, supporting the growth of the nuclear power industry with new standards in safety and performance.

As our name became synonymous with rock-solid, reliable mechanical buoyancy controls, we secured our core capabilities in electronic technologies, including RF capacitance and ultrasonic. Most recently, we started a legacy of world-class, award-winning radar instrumentation, which continues today with the Eclipse® Model 706 guided wave radar transmitter.

The MAGNETROL team of innovators has never looked back.

OUR PRODUCTS

The majority of the devices manufactured by Magnetrol® International are designed and tailor-made to the specifications and requests of our customers. Over the years a great expertise has been gained in different fields.

Below is a list, not limitative and depending on the device type, of metals with which we have gained experience:

- 321 stainless steel
- 304/304L stainless steel
- 316/316L stainless steel
- (Low temperature) Carbon steel and carbon steel
- Chrome Molybdenum steel
- (Super) Duplex stainless steel
- Monel
- Hastelloy
- Incolloy and Inconel types
- ….

Working with these various metals has resulted in over 130 in-house welding procedures being established.

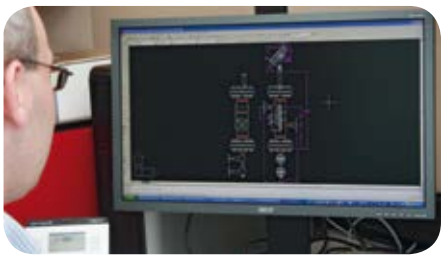
A similar experience has been gained with respect to possible process connections:

- ANSI flanges
- EN (DIN) flanges
- Tri-clamp hygienic connections
- Proprietary flanges enabling compatibility with existing connections
- Threaded connections such as NPT and BSP
- …

Although our standard colours are blue (up to 240 °C (464 °F)) and a grey type (temperatures higher than 240 °C (464 °F)) we can supply nearly any colour upon customer request.

So, if you have any specific request please do not hesitate to contact us.

TECHNOLOGY	PRODUCT FAMILY	PAGE	Detection liquid level	Detection interface	Detection flow	Density control	Measurement liquid level	Measurement solids level	Measurement interface	Measurement Flow
Guided Wave Radar	Eclipse® – Horizon™	6					•	•	•	•
Pulse Burst Radar	Pulsar® - Model R82	20					•			•
Ultrasonic Contact	Echotel® 9XX	24	•							
Ultrasonic Non-Contact	Echotel® 3X5	30					•			•
Thermal Dispersion	Thermatel®	34	•	•	•					•
Electromagnetic Flow Meter	Polaris®	40								•
RF Capacitance	Kotron®	42					•	•	•	
Magnetostrictive	Jupiter®	46					•		•	
Magnetic Level Indicator	Aurora®/Vector™/Atlas™/Gemini™	48					•		•	
Displacer Transmitter	Modulevel®	54				•	•		•	
Buoyancy	Mechanicals	58	•	•						
Mechanical Flow	Mechanicals	66			•					



Magnetrol® level and flow controls use state-of-the-art technology and are produced under strict quality procedures of ISO 9001 - PED 2014/68/EU. MAGNETROL quality is achieved by using fully traceable materials, ASME IX qualified welders and the capability to work with standard as well as exotic materials. MAGNETROL builds standard and custom equipment for all industries. The integration of SIL (Safety Integrity Level) philosophy into the basic concept design results in reliable controls that self-test for proper operation and report any possible malfunctions. MAGNETROL is devoted to optimizing the design of level controls for minimal cost of ownership by durability.

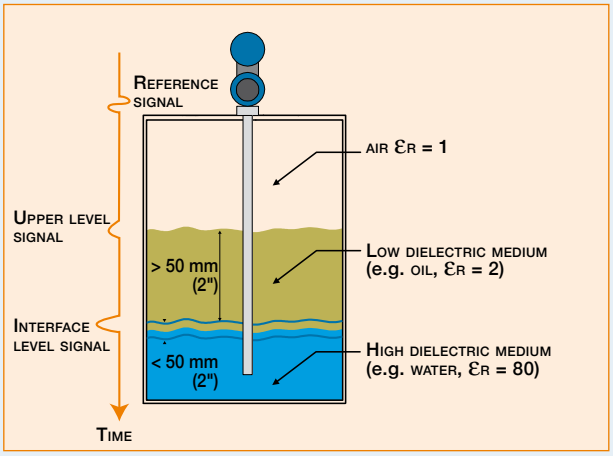
Full details on MAGNETROL products can be found on our website www.magnetrol.com and in our respective sales bulletins.

GUIDED WAVE RADAR

Guided Wave Radar is based upon the principle of Time Domain Reflectometry (TDR). TDR utilises pulses of ele - tromagnetic energy, which are transmitted down a probe. When a pulse reaches a liquid surface that has a higher dielectric than the air/vapour in which it is traveling, the pulse is reflected

An ultra high-speed timing circuit precisely measures the transit time and provides an accurate measurement of the liquid level or the liquid-liquid interface.

Many of these devices are overfill safe due to the fact that the reference signal is generated above the process seal.



eclipse.magnetrol.com

ECLIPSE® 706

Guided wave radar level transmitter

DESCRIPTION

Eclipse® Model 706 is an advanced two wire loop powered, 24 V DC guided wave radar transmitter with a superior signal strength to take on a broad range of challenging high pressure high temperature applications. An extensive line of dedicated coaxial, caged coaxial, single and twin rod probes delivers accurate and reliable level control.

The innovative dual compartment enclosure positions wiring and electronics in the same plane, and angled to maximise ease of wiring, configuration, set-up and data display.

FEATURES

- "Real Level", measurement not affected by media variables eg. dielectrics, pressure, density, pH, viscosity, ...
- Easy bench configuration - no need for level movement.
- 2-wire loop powered intrinsically safe level transmitter.
- 360° rotatable housing can be dismantled without depressurising the vessel via "Quick connect/disconnect" probe coupling.
- Probe designs: up to +450 °C / 430 bar (+850 °F / 6250 psi).
- Saturated steam applications up to 155 bar @ +345 °C (2250 psi @ +650 °F).
- Cryogenic applications down to -196 °C (-320 °F).
- Integral or remote mount electronics.
- SIL 2 / SIL 3 capable certified.
- Unique overfill feature.
- Higher pulse amplitude and superior signal-to-noise ratio (SNR).
- 4-button user interface and graphical LCD display provide enhanced depth of data, indicating on-screen waveforms and troubleshooting tips.
- Can be programmed to automatically capture waveform data by time or by event occurrence.
- Contains pro-active build-up diagnostics.
- Potted electronics.

APPLICATIONS

MEDIA: Liquids or slurries; hydrocarbons to water-based media (dielectric 1.4 - 100) and solids (dielectric 1.9 - 100). Open channel flow flumes and weirs.

VESSELS: Most process or storage vessels up to rated probe temperature and pressure.

CONDITIONS: All level measurement and control applications including process conditions exhibiting visible vapours, foam, surface agitation, bubbling or boiling, high fill/empty rates, low level and varying dielectric media or specific gravity.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•	•	•				
CCOE	•	•						
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)	•	•	•	•				Metrology
IEC	•	•	•	•				
Inmetro	•	•	•	•				
SIL	SIL 2 (1oo1)							
Marine	Lloyd's Register of Shipping (LRS)							

Other approvals are available, consult factory for more details

ECLIPSE® 706
PROBE SELECTION
Coaxial GWR probes - liquides

Application/Type	7yT	7yP	7yD	7yS
Function	Level - Interface Standard temp	Level - Interface High pressure	Level - Interface HTHP	Saturated steam Steam probe
Overfill saf	Yes	Yes	Yes	No
Temperature				
-40 / +65 °C (-40 / +150 °F)	Yes	Yes	Yes	Yes
-40 / +200 °C (-40 / +400 °F)	Yes	Yes	Yes	Yes
-196 / +200 °C (-320 / +400 °F)	No	Yes	Yes	No
-196 / +450 °C (-320 / +850 °F)	No	No	Yes	No
-50 / +345 °C (-58 / +650 °F)	No	No	Yes	Yes
saturated steam	No [2]	No	No	Yes
Max pressure				
70 bar (1000 psi)	Yes	Yes	Yes	Yes
88 bar (1275 psi)	No	Yes	Yes	Yes
431 bar (6250 psi)	No	Yes	Yes	No
Dielectrics [1]				
ϑ 1.4	Yes	Yes	Yes	No
ϑ 1.7	Yes	Yes	Yes	No
ϑ 4	Yes	Yes	Yes	No
ϑ 10	Yes	Yes	Yes	Yes
Available probe length				
Standard	0,3 to 6,1 m (12 to 240")	0,3 to 6,1 m (12 to 240")	0,3 to 6,1 m (12 to 240")	0,6 to 6,1 m (24 to 240")
Enlarged	9 m (30')	9 m (30')	9 m (30')	N/A
Material of construction				
316/316L (1.4401/1.4404)	Yes	Yes	Yes	Yes
Hastelloy® C (2.4819)	Yes	Yes	Yes	Yes
Monel® (2.4360)	Yes	Yes	Yes	No
PFA insulated 316/316L rod	No	No	No	No
Process seal type	Teflon® TFE with Viton® o-rings [3] [5]	Hermetic glass ceramic, Inconel	Hermetic glass ceramic, Inconel	Hermetic glass ceramic, PEEK HT, Inconel
Vacuum service	Negative pressure, but no hermetic seal	Full vacuum	Full vacuum	Full vacuum
Viscosity cP (mPa.s)	500/2000	500/2000	500/2000	500
Liquid	small enlarged	small enlarged	small enlarged	
Clean	Yes Yes	Yes Yes	Yes Yes	Yes
Film coating	Yes Yes	Yes Yes	Yes Yes	Yes
Moderate build-up	No Yes	No Yes	No Yes	No
Strong build-up	No No	No No	No No	No
Min req. process conn.				
Small	3/4"	3/4"	2"	2"
Enlarged	3" [4]	3" [4]	3" [4]	N/A

[1] 1.2 min dielectric when end of probe analysis can be enabled.
[2] Acceptable up to 150 °C (300 °F) max with aegis o-rings.
[3] Other o-ring materials available (Kalrez®, Aegis,...).
[4] Outer probe ø 45 mm (1.75") (SST) or 49 mm (1.90") (exotic material) or 64 mm (2.50") (segmented).
[5] Special HF acid probe available upon request.

ECLIPSE® 706
PROBE SELECTION
Caged GWR probes - liquides

Application/Type	7yG	7yL	7yJ
Function	Level - Interface Standard temp	Level - Interface High pressure	Level - Interface HTHP
Overfill saf	Yes	Yes	Yes
Temperature			
-40 / +65 °C (-40 / +150 °F)	Yes	Yes	Yes
-40 / +200 °C (-40 / +400 °F)	Yes	Yes	Yes
-196 / +200 °C (-320 / +400 °F)	No	Yes	Yes
-196 / +450 °C (-320 / +850 °F)	No	No	Yes
-50 / +300 °C (-58 / +575 °F)	No	No	Yes
saturated steam	No	No	No
Max pressure			
70 bar (1000 psi)	Yes	Yes	Yes
88 bar (1275 psi)	No	Yes	Yes
431 bar (6250 psi)	No	Yes	Yes
Dielectrics [1]			
ϑ 1.4	Yes [2]	Yes [2]	Yes [2]
ϑ 1.7	Yes	Yes	Yes
ϑ 4	Yes	Yes	Yes
ϑ 10	Yes	Yes	Yes
Available probe length	0,3 to 6,1 m (12 to 240")	0,3 to 6,1 m (12 to 240")	0,3 to 6,1 m (12 to 240")
Material of construction			
316/316L (1.4401/1.4404)	Yes	Yes	Yes
Hastelloy® C (2.4819)	Yes	Yes	Yes
Monel® (2.4360)	Yes	Yes	Yes
PFA insulated 316/316L rod	No	No	No
Process seal type	Teflon® TFE with Viton® o-rings [3] [4]	Hermetic glass ceramic, Inconel	Hermetic glass ceramic, Inconel
Vacuum service	Negative pressure, but no hermetic seal	Full vacuum	Full vacuum
Viscosity cP (mPa.s)	10000	10000	10000
Liquid			
Clean	Yes	Yes	Yes
Film coating	Yes	Yes	Yes
Moderate build-up	Yes	Yes	Yes
Strong build-up	Yes	Yes	Yes
Min req. process conn.	2"	2"	2"

[1] 1.2 min dielectric when end of probe analysis can be enabled.
[2] When installed in the proper chamber/cage/stilling well.
[3] Other o-ring materials available (Kalrez®, Aegis,...).
[4] Special HF acid probe available upon request.

ECLIPSE® 706
PROBE SELECTION
Single rod rigid GWR probes - liquides

Application/Type	7yF	7yM	7yN
Function	Level Standard temp	Level High pressure	Level HTHP
Overfill saf	No [2]	No [2]	No [2]
Temperature			
-40 / +65 °C (-40 / +150 °F)	Yes	Yes	Yes
-40 / +200 °C (-40 / +400 °F)	Yes	Yes	Yes
-196 / +200 °C (-320 / +400 °F)	No	Yes	Yes
-196 / +450 °C (-320 / +850 °F)	No	No	Yes
-50 / +300 °C (-58 / +575 °F)	No	No	Yes
saturated steam	No	No	No
Max pressure			
70 bar (1000 psi)	Yes	Yes	Yes
88 bar (1275 psi)	No	Yes	Yes
431 bar (6250 psi)	No	Yes	Yes
Dielectrics [1]			
ϑ 1.4	No	No	No
ϑ 1.7	Yes	Yes	Yes
ϑ 4	Yes	Yes	Yes
ϑ 10	Yes	Yes	Yes
Available probe length	0,6 to 7,32 m (24 to 288")	0,6 to 7,32 m (24 to 288")	0,6 to 7,32 m (24 to 288")
Material of construction			
316/316L (1.4401/1.4404)	Yes	Yes	Yes
Hastelloy® C (2.4819)	Yes	Yes	Yes
Monel® (2.4360)	Yes	Yes	Yes
PFA insulated 316/316L rod	Yes	No	No
Process seal type	Teflon® TFE with Viton® o-rings [3]	Hermetic glass ceramic, Inconel	Hermetic glass ceramic, Inconel
Vacuum service	Negative pressure, but no hermetic seal	Full vacuum	Full vacuum
Viscosity cP (mPa.s)	10000	10000	10000
Liquid			
Clean	Yes	Yes	Yes
Film coating	Yes	Yes	Yes
Moderate build-up	Yes	Yes	Yes
Strong build-up	Yes	Yes	Yes
Min req. process conn.	2" [4]	2" [4]	2"

[1] 1.2 min dielectric when end of probe analysis can be enabled.
[2] Overfill capability can be achieved via software.
[3] Other o-ring materials available (Kalrez®, Aegis,...).
[4] 1" threaded connection available.

ECLIPSE® 706
PROBE SELECTION
Flexible GWR probes - liquides

Application/Type	7y1	7y3	7y6	7y7
Function	Level Single flexible Standard temp	Level Single flexible HP	Level - Interface Single flexible HTHP	Level - Interface Twin flexible Standard temp
Overfill saf	No [2]	No [2]	No [2]	No [2]
Temperature				
-40 / +65 °C (-40 / +150 °F)	Yes	Yes	Yes	Yes
-40 / +200 °C (-40 / +400 °F)	Yes	Yes	Yes	Yes
-196 / +200 °C (-320 / +400 °F)	No	Yes	Yes	No
-196 / +450 °C (-320 / +850 °F)	No	Yes	Yes	No
-50 / +300 °C (-58 / +575 °F)	No	Yes	Yes	No
saturated steam	No	No	No	No
Max pressure				
70 bar (1000 psi)	Yes	Yes	Yes	Yes
88 bar (1275 psi)	No	Yes	Yes	No
431 bar (6250 psi)	No	Yes	Yes	No
Dielectrics [1]				
ϑ 1.4	No	No	Yes [3]	No
ϑ 1.7	Yes [4]	Yes [4]	Yes	Yes [4]
ϑ 4	Yes	Yes	Yes	Yes
ϑ 10	Yes	Yes	Yes	Yes
Available probe length	1 to 30 m (3 to 100')	1 to 30 m (3 to 100')	1 to 30 m (3 to 100')	1 to 30 m (3 to 100')
Material of construction				
316/316L (1.4401/1.4404)	Yes	Yes	Yes	Yes
Hastelloy® C (2.4819)	No	No	No	No
Monel® (2.4360)	No	No	No	No
PFA insulated 316/316L cable	Yes	No	No	No
Process seal type	Teflon® TFE with Viton® o-rings [5]	Hermetic glass ceramic	Hermetic glass ceramic	Teflon® TFE with Viton® o-rings [5]
Vacuum service	Negative pressure, but no hermetic seal	Full vacuum	Full vacuum	Negative pressure, but no hermetic seal
Viscosity cP (mPa.s)	10000	10000	10000	1500
Liquid				
Clean	Yes	Yes	Yes	Yes
Film coating	Yes	Yes	Yes	Yes
Moderate build-up	Yes	Yes	Yes	No
Strong build-up	Yes	Yes	Yes	No
Min req. process conn.	2"	2"	2"	2"

[1] 1.2 min dielectric when end of probe analysis can be enabled.
[2] Overfill capability can be achieved via software.
[3] When installed in the proper chamber/cage/stilling well.
[4] May increase with probe length >10 m (30').
[5] Other o-ring materials available (Kalrez®, Aegis,...).

ECLIPSE® 706
PROBE SELECTION
Flexible GWR probes - solids

Application/Type	7y2	7y5
Function	Level Single flexible Standard temp	Level Twin flexible Standard temp
Overfill saf	No [2]	No [2]
Temperature		
-40 / +65 °C (-40 / +150 °F)	Yes	Yes
-40 / +200 °C (-40 / +400 °F)	No	No
-196 / +200 °C (-320 / +400 °F)	No	No
-196 / +450 °C (-320 / +850 °F)	No	No
-50 / +300 °C (-58 / +575 °F)	No	No
saturated steam	No	No
Max pressure	Atmos	Atmos
Dielectrics [1]		
ϑ 1.4	No	No
ϑ 1.7	No	Yes [3]
ϑ 4	Yes	Yes
ϑ 10	Yes	Yes
Available probe length	1 to 30 m (3 to 100')	1 to 30 m (3 to 100')
Material of construction		
316/316L (1.4401/1.4404)	Yes	Yes
Hastelloy® C (2.4819)	No	No
Monel® (2.4360)	No	No
PFA insulated 316/316L rod	No	No
Process seal type	Teflon® / PEI [4]	Teflon® / PEI [4]
Vacuum service	Negative pressure, but no hermetic seal	Negative pressure, but no hermetic seal
Viscosity cP (mPa.s)	10000	1500
Liquid		
Clean	Yes	Yes
Film coating	Yes	Yes
Moderate build-up	Yes	No
Strong build-up	Yes	No
Min req. process conn.	2" min	2" min

[1] 1.2 min dielectric when end of probe analysis can be enabled.
[2] Overfill capability can be achieved via software.
[3] May increase with probe length >10 m (30').
[4] PEI = Ultem™ 1000.

ECLIPSE® 705

Guided wave radar level transmitter

DESCRIPTION

Eclipse® 705 Transmitter is a loop-powered, 24 V DC liquid-level transmitter based on the revolutionary Guided Wave Radar (GWR) technology. Encompassing a number of significant engineering accomplishments, this leading edge level transmitter is designed to provide measurement performance well beyond that of many traditional technologies, as well as "through-air" radars.

The innovative enclosure is a first in the industry, orienting dual compartments (wiring and electronics) in the same plane, and angled to maximise ease of wiring, configuration, set-up and data display.

This single transmitter can be used with all probe types and offers enhanced reliability, for use in SIL2 / SIL 3 loops.

FEATURES

- "Real Level", measurement not affected by media variables eg. dielectrics, pressure, density, pH, viscosity, ...
- Easy bench configuration - no need for level simulation.
- 2-wire loop powered intrinsically safe level transmitter.
- 20-point custom strapping table for volumetric output.
- 360° rotatable housing can be dismantled without depressurising the vessel via "Quick connect/disconnect" probe coupling.
- 2-line x 8-characters display and 3-button keypad.
- Probe designs: up to +425 °C / 430 bar (+800 °F / 6250 psi).
- Saturated steam applications up to 155 bar @ +345 °C (2250 psi @ +650 °F).
- Cryogenic applications down to -196 °C (-320 °F).
- Integral or remote electronics.
- Suited for SIL 1 or SIL 2 Loops (full FMEDA report available).
- Suited for SIL 3 Loops (EXIDA Certificate available).

APPLICATIONS

MEDIA: Liquids or slurries; hydrocarbons to water-based media (dielectric 1,4 - 100) and solids (dielectric 1,9 - 100).

VESSELS: Most process or storage vessels up to rated probe temperature and pressure.

CONDITIONS: All level measurement and control applications including process conditions exhibiting visible vapours, foam, surface agitation, bubbling or boiling, high fill/empty rates, low level and varying dielectric media or specific gravity.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•	•	•				
CCOE	•	•						
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)	•	•						Metrology
IEC	•	•						
Inmetro	•	•						
Korea	•	•						
NEPSI								CPA

Marine	Lloyd's Register of Shipping (LRS)
SIL	SIL1/2 (1oo1)
Steam Drum	Lloyds EN 12952-11 (water tube boilers) Lloyds EN 12953-9 (shell boilers)
TÜV	WHG § 63, overfill prevention

Other approvals are available, consult factory for more details

ECLIPSE® 705 HEAVY DUTY

Guided wave radar probes for heavy duty applications

DESCRIPTION

Eclipse® 705 Transmitter is a loop-powered, 24 V DC liquid-level transmitter based on the revolutionary Guided Wave Radar (GWR) technology. Encompassing a number of significant engineering accomplishments, this leading edge level transmitter is designed to provide measurement performance well beyond that of many traditional technologies, as well as "through-air" radars.

The innovative enclosure is a first in the industry, orienting dual compartments (wiring and electronics) in the same plane, and angled to maximise ease of wiring, configuration, set-up and data display.

This single transmitter can be used with all probe types and offers enhanced reliability, for use in SIL 2 / SIL 3 loops.

FEATURES

- "Real Level", measurement not affected by media variables eg. dielectrics, pressure, density, pH, viscosity, ...
- Easy bench configuration - no need for level simulation.
- 2-wire loop powered intrinsically safe level transmitter.
- 20-point custom strapping table for volumetric output.
- 360° rotatable housing can be removed without depressurising the vessel via "Quick connect/ disconnect" probe coupling.
- 2-line x 8 characters display and 3-button keypad.
- Probe designs: up to +425 °C / 430 bar (+800 °F / 6250 psi).
- Saturated steam applications up to 155 bar @ +345 °C (2250 psi @ +650 °F).
- Cryogenic applications down to -196 °C (-320 °F).
- Integral or remote electronics.
- Suited for SIL 1 or SIL 2 Loops (full FMEDA report available).
- Suited for SIL 3 Loops (EXIDA Certificate available).

APPLICATIONS

MEDIA: Liquids or slurries; hydrocarbons to water-based media (dielectric 1,4 - 100), up to 10.000 cP.

VESSELS: Most process or storage vessels up to rated probe temperature and pressure.

CONDITIONS: All level measurement and control applications including process conditions exhibiting visible vapours, foam, surface agitation, bubbling or boiling, high fill/empty rates, low level and varying dielectric media or specific gravity.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•	•	•				
CCOE	•	•						
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)	•	•						Metrology
IEC	•	•						
Inmetro	•	•						
Korea	•	•						
NEPSI								CPA

Marine	Lloyd's Register of Shipping (LRS)
SIL	SIL1/2 (1oo1)
Steam Drum	Lloyds EN 12952-11 (water tube boilers) Lloyds EN 12953-9 (shell boilers)
TÜV	WHG § 63, overfill prevention

Other approvals are available, consult factory for more details

ECLIPSE® 705
PROBE SELECTION
Coaxial style GWR probes

Application/Type	7MR-7MM (coax)	7MD-7ML (coax)	7MS /7MQ (coax)	7MT-7MN (coax)	7MG (single rod) [2]
Function	Level	HTHP[1]	Steam	Level - Interface	Level - Interface
Temperature					
-40 / +150 °C (-40 / +300 °F)	Yes	Yes	No	Yes	Yes
-40 / +200 °C (-40 / +400 °F)	Yes	Yes	No	Yes	Yes
-196 / +425 °C (-320 / +800 °F)	No	Yes	No	No	No
Up to +300 °C (+575 °F)	No	No	Saturated steam: 7MS: < 300 °C (575 °F) 7MQ: > 300 °C (575 °F)	No	No
Pressure					
0 to 50 bar (0 to 750 psi)	Yes	Yes	Yes	Yes	Yes
0 to 70 bar (0 to 1000 psi)	Yes	Yes	Yes	Yes	Yes
0 to 155 bar (0 to 2250 psi)	No	Yes	Yes	No	No
Vacuum to 430 bar (6250 psi)	No	Yes	No	No	No
Min. dielectrics		Level: 1.4 or 1.7 to 100 Interface: Upper liquid: 1.4 or 1.7 to 5.0 Lower liquid: 15 to 100		Level: 1.4 or 1.7 to 100 Interface: Upper liquid: 1.4 to 5.0 Lower liquid: 15 to 100	Level: 1.4 or 1.7 to 100 Interface: Upper liquid: 1.4 to 5.0 Lower liquid: 15 to 100
ϑ 1.4	Yes		No		
ϑ 1.7	Yes		No		
ϑ 1.9	Yes		No		
ϑ 10	Yes		Yes		
Available probe length	6,1 m (240")	6,1 m (240")	4,5 m (177")	6,1 m (240")	6,1 m (240")
Wetted materials					
316/316L	Yes	Yes	Yes	Yes	Yes
Hastelloy® C	Yes	Yes	No	Yes	Yes
Monel®	Yes	Yes	No	Yes	Yes
Seal type	"O"ring type with various materials	Borosilicate seal (Full vacuum)	Dynamic steam seal with HT PEEK / Aegis	"O"ring type with various materials	"O"ring type with various materials
Liquid					
Clean	Yes	Yes	Yes	Yes	Yes
Film coating	Yes	Yes	Yes	Yes	Yes
Weak build-up	Yes	Yes	Yes	Yes	Yes
Strong build-up	Use Ø 45 mm (1.75") (7MM)	Use Ø 45 mm (1.75") (7ML)	No	Use Ø 45 mm (1.75") (7MN)	Yes
aggressive	Yes	Yes	No	Yes	Yes
Probe Ø/section	Ø 22,5 (7MR) - 45 (7MM) mm (0.88 - 1.75")	Ø 22,5 (7MD) - 45 (7ML) mm (0.88 - 1.75")	Ø 22,5 mm (0.88")	Ø 22,5 (7MT) - 45 (7MN) mm (0.88 - 1.75")	Ø 13, 19 or 25 mm (0.5, 0.75 or 1")

[1] High Temperature / High Pressure (HTHP) GWR probes with multi venting holes are suitable for level and liquid-liquid interface measurement.
[2] Caged single rod probe with the same performance as a coax set up.

ECLIPSE® 705
PROBE SELECTION
Single and dual lead GWR probes

Application/Type	7MF-A (single rod)	7MF-F (single rod)	7MJ (single rod)	7M1/7M2 (single cable)	7MB (twin rod)	7M7/7M5 (twin flex	7MF-X / 7MH (single rod)
Function	Level liquids	PFA coated	HTHP	Liquids / Solids	Level - Interface	Liquids / Solids	Hygienic use
Temperature							
-40 / +150 °C (-40 / +300 °F)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
-40 / +200 °C (-40 / +400 °F)	No	No	Yes	Yes (7M1 only)	Yes	Yes (7M7) - ambient (7M5)	No
-40 / +315 °C (-40 / +600 °F)	No	No	Yes	As "X"(1)	No	No	No
Pressure							
0 to 70 bar (0 to 1000 psi)	Yes	Yes	Yes	Yes	Yes	Yes	No
0 to 245 bar (0 to 3550 psi)	No	No	Yes	As "X"(1)	No	No	No
Min. dielectrics							
ϑ 1.4	No	No	No	7M1: ϑ 1.9 7M2: ϑ 4.0	No	No	No
ϑ 1.9	Yes	Yes	Yes		Yes	Yes	Yes
ϑ 10	Yes	Yes	Yes		Yes	Yes	Yes
Available probe length	6,1 m (240")	6,1 m (240")	6,1 m (240")	22 m (72.18')	6,1 m (240")	22 m (72.18')	6,1 m (240")
Wetted materials							
316/316L	Yes	Yes	Yes	Yes	Yes	Yes - FEP insul.	Yes
Hastelloy® C	No	No	Yes	No	Yes	No	Yes
Monel®	No	No	Yes	No	Yes	No	No
AL-6XN	No	No	No	No	No	No	Yes
Seal type	"O"ring type with Viton®/EPDM/Kalrez® 4079/PEEK materials (not for use with ammonia, use only 7MD)						Hygienic
Liquid							
Clean	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Film coating	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weak build-up	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Strong build-up	Yes	Yes	Yes	Yes	Yes	No	Yes
aggressive	No	Yes	Yes	No	Yes	No	No
Probe Ø/section	Ø 13 mm (0.5")	Ø 16 mm (0,6")	Ø 13 mm (0.5")	Ø 5 mm (0.2")	2 x Ø 13 mm (0.5")	2 x Ø 6 mm (0.2")	Ø 13 mm (0.5")

Remote transmitter head
available as an option

(1) As "X" = optionally available.

ECLIPSE® 705 HYGIENIC

Guided wave radar level transmitter for hygienic use

BPE

DESCRIPTION

Eclipse® 705 Transmitter is a loop-powered, 24 V DC liquid-level transmitter based on the revolutionary Guided Wave Radar (GWR) technology. Encompassing a number of significant engineering accomplishments, this leading edge level transmitter is designed to provide measurement performance well beyond that of many traditional technologies, including "through-air" radar.

Typical for these devices is that the probe can be bended (upon request) to follow the shape of the vessel. This way mixing blades can be avoided and measurement can be carried out to the last drop present.

ECLIPSE 705 offers enhanced reliability, as demonstrated by a Safe Failure Fraction of 91 %.

FEATURES

- "Real Level", measurement not affected by media variables eg. dielectrics, pressure, density, pH, viscosity, ...
- 2-wire loop powered intrinsically safe level transmitter.
- 20-point custom strapping table for volumetric output.
- Housing can be removed without depressurising the vessel.
- 2-line x 8 characters display and 3-button keypad.
- Suitable design for CIP/SIP cleaning.
- Integral or remote electronics.
- Suited for SIL 1 or SIL 2 Loops (full FMEDA report available).

APPLICATIONS

MEDIA: From non-conductive liquids up to water-based media (dielectric 1,9 - 100).

VESSELS: Most process or storage vessels.

CONDITIONS: All level measurement and control applications including process conditions exhibiting visible vapours, foam, surface agitation, bubbling or boiling, high fill/empty rates, low level and varying dielectric media or specific gravity.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX		•						
CCOE		•						
CSA						•	•	
FM						•	•	
EAC (GOST)		•						Metrology
IEC		•						
SIL	SIL1/2 (1oo1)							
TNO	Hygienic Machinery Directive 98/37/EC annex 1, section 2,1 EN 1672 part 2, Hygienic requirements EHEDG doc. 2 (second edit. March 2000) and doc. 8 (July 1993)							

Other approvals are available, consult factory for more details

HORIZON™ 704
Guided wave radar level transmitter

DESCRIPTION

Horizon™ 704 is a loop-powered, 24 V DC liquid-level transmitter based on the revolutionary Guided Wave Radar (GWR) technology. The electronics of the HORIZON 704 is integral mount on the GWR probe and allows local configuration via a 3-button keypad / display. HORIZON 704 electronics are compatible with different types of GWR probes each encompassing different application challenges (coaxial or twin rod types). The aluminium or Lexan® housing can be removed for service under process conditions.

FEATURES

- "Real Level", measurement not affected by changing media variables eg. dielectrics, pressure, density, pH, viscosity, ...
- Easy bench configuration - no need for level simulation.
- 2-line x 8 characters display / 3-button keypad or blind transmitter.
- 2-wire loop powered intrinsically safe level transmitter.
- Housing can be easily removed without depressurising the vessel.
- HART®/AMS® digital communication.
- Max process temperature: +205 °C (+400 °F).
- Max process pressure: 70 bar (1000 psi).
- 4-20 mA output (meets NAMUR NE 43).
- Integral mount electronics.

APPLICATIONS

MEDIA: Liquids or slurries; hydrocarbons to water-based media (dielectric 1,7 - 100).

VESSELS: Most process or storage vessels up to rated probe temperature and pressure.

CONDITIONS: All level measurement and control applications including process conditions exhibiting visible vapours, foam, coating / build-up, surface agitation, turbulence and varying dielectric media or specific gravity.

AGENCY APPROVALS

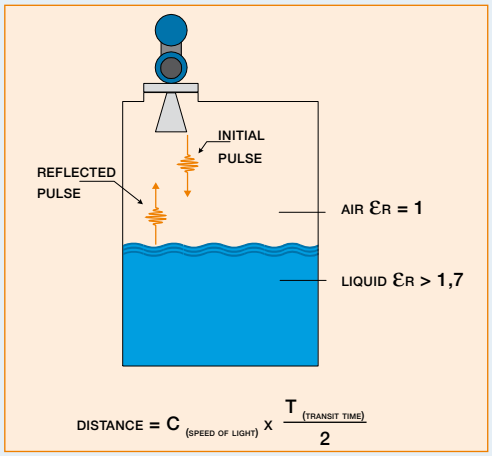
	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX		•						
CSA					•	•	•	
FM					•	•	•	

Other approvals are available, consult factory for more details

PULSE BURST RADAR

Pulse Burst Radar emits short bursts of energy to a liquid surface. Ultra-high-speed timing circuitry measures the time of the signal reflected o f the liquid surface.

Sophisticated signal processing filters out false eflections and other background noises. The exact level is then calculated, by factoring in tank height and other configuration information. The circuitry is extremely energy efficient so no duty cycling is needed as with other radar devices. This allows the device to track high rates of level changes up to 4,5 m/minute (180"/min).



HART COMMUNICATION PROTOCOL

PULSAR® R86

Pulse burst radar level transmitter

DESCRIPTION

Pulsar® Model R86 Radar transmitter is the latest generation of an advanced loop-powered 4–20 mA level transmitter with proactive diagnostics provides accurate measurement even in shifting dielectric and varying media.

FEATURES

- 26 GHz frequency offers smaller beam angle and improved resolution.
- 2-wire loop powered intrinsically safe level transmitter.
- 360° rotatable housing can be dismantled without depressurising the vessel via “Quick connect/disconnect” antenna coupling.
- 4-button user interface and graphical LCD display provide enhanced depth of data, indicating on-screen waveforms and troubleshooting tips.
- Wide range of HTHP antennas, with extensions.
- Coated Isolation antennas for corrosive applications (future).
- False target setup is simple, intuitive and effective.
- Unique commissioning and optimization wizards.
- Proactive diagnostics.
- Full vacuum to 160 bar (2320 psi); -70 °C to +400 °C (-100 °F to +750 °F).
- Measuring range up to 40 m (130 Feet).
- Suited for SIL 1 and SIL 2 loops (full FMEDA report available).
- Can be programmed to automatically capture waveform data by time or by event occurrence.
- Potted electronics.

APPLICATIONS

Liquids and slurries, hydrocarbons to water-based media, high temperature/high pressure process or storage vessels.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)								Metrology
IEC	•	•						
SIL	SIL 2 (1oo1)							

Other approvals are available, consult factory for more details

PULSAR® R96
Pulse burst radar level transmitter

DESCRIPTION

Pulsar® Radar transmitter is a loop-powered, 24 V DC, level transmitter. It has low power consumption, fast response time and is easy to use.

PULSAR is designed to provide unparalleled performance and ease of use. PULSAR non-contact radar is the perfect complement to the Magnetrol® Eclipse® Guided Wave Radar. These transmitters offer the ultimate solution to the vast majority of process level applications.

FEATURES

- 6 GHz operating frequency offers superior performance in the tougher applications of turbulence, foam, and heavy vapours.
- 2-wire loop powered intrinsically safe level transmitter.
- 360° rotatable housing can be dismantled without depressurising the vessel via “Quick connect/disconnect” antenna coupling.
- 4-button user interface and graphical LCD display provide enhanced depth of data, indicating on-screen waveforms and troubleshooting tips.
- 2 antenna styles up to +200 °C / 51,7 bar (+400 °F / 750 psi):
  - horn antenna: 3", 4" and 6"
  - dielectric rod antenna: Polypropylene and TFE.
- Measuring range up to 40 m (130 Feet).
- False target setup is simple, intuitive and effective.
- Will reliably track extremely rapid rate of change up to 4,5 m (180") / minute.
- Suited for SIL 1 and SIL 2 loops (full FMEDA report available).
- Can be programmed to automatically capture waveform data by time or by event occurrence.
- Potted electronics.

APPLICATIONS

MEDIA: Liquids or slurries; hydrocarbons to water-based media (dielectric 1,7 - 100).

VESSELS: Most process or storage vessels up to rated probe temperature and pressure.

CONDITIONS: Virtually all level measurement and control applications including process conditions exhibiting visible vapours, some foam, surface agitation, bubbling or boiling, high fill/empty rates, low level and varying dielectric media or specific gravity.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)								Metrology
IEC	•	•						
SIL	SIL 2 (1oo1)							

Other approvals are available, consult factory for more details

MODEL R82

Non-contact radar level transmitter for level, volume and open channel flow applications

DESCRIPTION

Model R82 is an economical, loop powered radar transmitter bringing radar to everyday applications. Ultrasonic devices, frequently used in daily applications, can now be replaced using radar technology with its superior performance.

The electronics are housed in a single compartment cast aluminium or Lexan® housing. R82 measures effectively even when atmospheres above the liquid are saturated with vapour. Pulse Burst technology and advanced signal processing manage common disturbances such as false echoes caused by obstructions, multi-path reflections from tank sidewalls or turbulence caused by agitators, aggressive chemicals, or aerators.

FEATURES

- 2-wire loop powered intrinsically safe transmitter.
- 26 GHz frequency.
- Fast and easy configuration via 2-line x 16 characters display and 4-button keypad.
- Intuitive false target profiling.
- Rotatable microwave beam for optimised operation.
- Encapsulated PP or Tefzel® antennas in lengths of 50 mm (2") and 200 mm (8").
- Process
  - temperature: -40 °C to +93 °C (-40 °F to +200 °F)
  - pressure: vacuum to 13,8 bar (200 psi)
  - dielectric: 1,7 – 100.
- Suited for SIL 1 loops (full FMEDA report available).

APPLICATIONS

- Open channel flow flumes and weirs.
- Paint, ink and solvent tanks.
- Chemical storage.
- Thick and viscous media.
- Batch and day tanks.

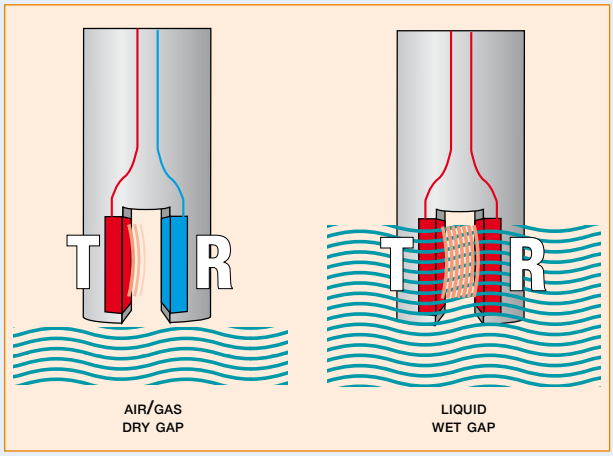
AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX		•						
CCOE		•						
cFMus						•	•	
EAC (GOST)		•						Metrology
IEC		•						
Inmetro		•						
SIL	SIL 1 (1oo1)							

Other approvals are available, consult factory for more details

ULTRASONIC CONTACT

Echotel® ultrasonic contact operates on a two crystal pulsed or “transmit-receive” principle which applies a high frequency electronic burst to the transmit crystal. The signal is then converted into ultrasonic energy and transmitted across the sensing gap towards the receiver crystal. When there is air in the gap, the high frequency ultrasonic energy will be attenuated, thereby not allowing the energy to be received. When there is liquid in the gap, the ultrasonic energy will propagate across the gap and the current shift or relay output will indicate a reception of the signal.



echotel.magnetrol.com

ECHOTEL® 961/962
Ultrasonic level switch

DESCRIPTION

Echotel® 961/962 series are used to detect high or low level alarm(s) in a broad range of liquids. Pulsed signal technology provides superior performance in applications suffering from foam, aeration, heavy turbulence and suspensions containing solids.

ECHOTEL 961 has a tip sensitive setpoint and is ideally used as high or low level alarm.

ECHOTEL 962 offers 2 setpoints on the same transducer, a tip sensitive setpoint and a second setpoint via a flow-through upper gap. The unit is used for level alarm or to control a pump in an auto fill/empty mode.

ECHOTEL 961/962 is equipped with advanced diagnostics that continuously check the transducer and electronics. The diagnostics also alarm for electrical noise interference from external sources.

FEATURES

- No calibration required.
- 2-wire loop powered with mA output or AC/DC line powered with integrated relay(s).
- Continuous selftest with selectable error output.
- LED identification for:
  - process alarm
  - error of transducer, electronics or electrical noise interference
  - wet/dry status of transducer.
- Push buttons for manual testing of alarm and error signals.
- Adjustable time delay up to 45 s.
- Process temperature from -80 °C to +165 °C (-110 °F to +325 °F) depending on used materials.
- Process pressure up to 138 bar (2000 psi).
- Metal and plastic transducers.
- Suited for SIL 1 and SIL 2 loops (full FMEDA report available).
- Remote electronics.

APPLICATIONS

VESSELS: Any mounting position.

CONDITIONS: Unaffected by

- shifting dielectric, density or pH
- presence of foam, turbulence, visible vapours
- fast drain/fill rates
- transducer coating and air bubbles
- vacuum conditions.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE	•	•						
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)	•	•						
IEC	•							
Inmetro	•	•						
SIL	SIL 2 (1oo1)							
TÜV	WHG § 63, overfill prevention							

Other approvals are available, consult factory for more details

ECHOTEL® 961
Ultrasonic level switch for hygienic use

BPE

DESCRIPTION

Echotel® 961 ultrasonic level switches require no calibration to detect the presence of any liquid in less than 1s. Foam is ignored by this technology, so that the unit only detects the presence or absence of liquid. The pulsed wave technology permits the unit to resist turbulence, aeration, suspended solids and build-up.

ECHOTEL 961 has both 3A and EHEDG approval for use in hygienic applications.

ECHOTEL 961 offers either current shift or relay output.

FEATURES

- No calibration required.
- 2-wire loop powered with mA output, AC/DC line powered with integrated relays.
- Continuous selftest with selectable error output.
- Process temperature from -40 °C to +165 °C (-40 °F to +325 °F).
- Process pressure up to 103 bar (1500 psi).
- LED identification for:
  - process alarm
  - error of transducer, electronics or electrical noise interference
  - wet/dry status of transducer.
- Push buttons for manual testing of alarm and error signals.
- Adjustable time delay up to 45 s.
- Suitable sensor design for CIP/SIP cleaning.
- Suited for SIL 1 and SIL 2 loops (full FMEDA report available).
- Hygienic connections.

APPLICATIONS

MEDIA: Any liquid.

VESSELS: Any mounting position.

CONDITIONS: Unaffected by

- shifting dielectric, density or pH
- presence of foam, turbulence, visible vapours
- fast drain/fill rates
- vacuum conditions.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
CSA						•	•	
FM						•	•	
SIL	SIL 2 (1oo1)							
TNO	Hygienic Machinery Directive 98/37/EC annex 1, section 2,1 EN 1672 part 2, Hygienic requirements EHEDG doc. 2 (second edit. March 2000) and doc. 8 (July 1993)							

Other approvals are available, consult factory for more details

ECHOTEL® 910
Ultrasonic tip sensitive level control

DESCRIPTION

Echotel® 910 is an integral mounted ultrasonic tip sensitive level switch with integrated DPDT relay. ECHOTEL 910 is ideally suited for seal pots, OEMs, overflow prevention, high or low level alarm in clean liquid applications with or without foam.

FEATURES

- No calibration required.
- Dual electrical entries and various housings are standard available.
- A built-in averaging circuit ensures no false alarms due to most effervescence or turbulences.
- Actuation is determined by the length of the transducer and is available in lengths between 3 cm (1") and 254 cm (96").
- Process pressure/temperature: 55,2 bar at -40 °C to +120 °C (800 psi at -40°F to +250 °F).
- All materials exposed to process in 316/316L SST (1.4401/1.4404).
- Field selectable high/low level failsafe.
- Optional universal nameplate.

APPLICATIONS

LIQUIDS: Any clean liquids.

VESSELS: Any mounting position.

PROCESS CONDITIONS: Unaffected by

- shifting dielectric, density or pH
- presence of foam, turbulence, visible vapours
- fast drain/fill rates
- transducer coating and air bubbles
- vacuum conditions.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•							
CCOE	•							
CSA					•		•	
FM					•		•	
EAC (GOST)	•							

Other approvals are available, consult factory for more details

ECHOTEL® 940/941
Ultrasonic level switch

DESCRIPTION

Echotel® 940/941 ultrasonic level controls are compact integral units which utilise pulsed wave technology to detect high or low level alarm in a broad range of viscous to light liquids.

The unit is available in two versions:
- with integrated relay: ECHOTEL 940
- with 8/16 mA current shift: ECHOTEL 941.

FEATURES

- No calibration required.
- Electronics potted in sensor.
- Compact and easy to install design.
- High or low level detection.
- Max +85 °C at 138 bar (+185 °F at 2000 psi).
- IP66, watertight, with flying leads.
- Horseshoe shaped transducer gap.

APPLICATIONS

VESSELS: Any mounting position, ideally suited for filters.

CONDITIONS: Unaffected by
- shifting dielectric, density or pH
- presence of foam, turbulence, visible vapours
- fast drain/fill rates
- vacuum conditions.

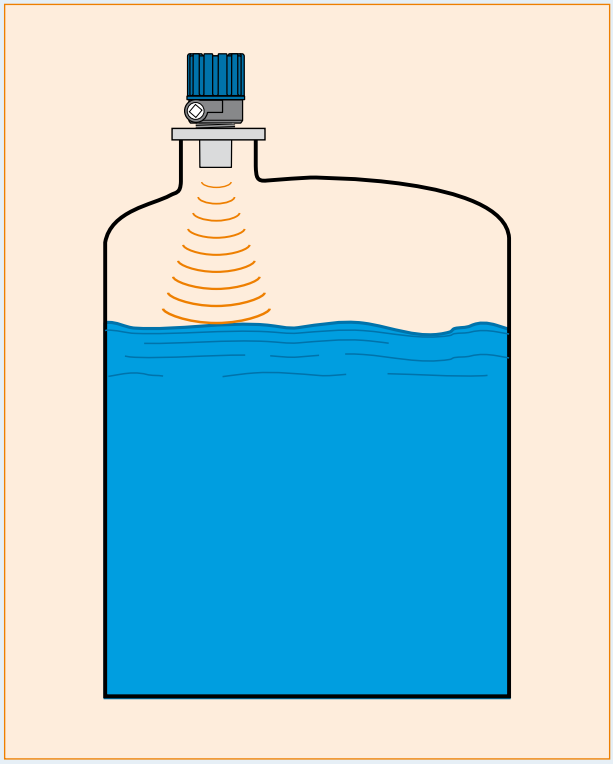
AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
CSA						•	•	
FM						•	•	

Other approvals are available, consult factory for more details

ULTRASONIC NON-CONTACT

The level measurement is accomplished by emitting an ultrasonic pulse from the transducer face and measuring the elapsed time between sending this pulse and its reflected echo from the liquid surface. Since the speed of sound is temperature dependant, the transducer also measures ambient temperature to compensate for the changing velocity.



SIL Ex HART COMMUNICATION PROTOCOL AMS PACTware FDT Connected

ECHOTEL® 355

Ultrasonic non-contact transmitter for level, volume or open channel flow

DESCRIPTION

Echotel® 355 is an integral mount, high performance ultrasonic non-contact transmitter for liquid level, volume and open channel flow measurement.

The electronics are housed in a single compartment cast aluminium or Lexan® housing. The intelligent electronics analyse the ultrasonic echo profile, apply temperature compensation, reject echoes from false targets, and then processes the true echo from the liquid surface. This results in an extremely reliable measurement even when application difficulties like turbulence and false echoes exist.

FEATURES

- 2-wire loop powered intrinsically safe transmitter.
- Fast and easy configuration via 2-line x 16 characters display and 4-button keypad.
- False target rejection identifies true echo from liquid surface.
- Common tank shapes and 20-point custom table for volume calculations.
- Flume/weir primary elements and generic equation for open channel flow.
- Process temperature from -40 °C to +80 °C (-40 °F to +175 °F).
- Process pressure max 3 bar (43,5 psi).
- Two 7-digit totalizers for flow:
  - resettable
  - continuous totalizer.
- Suited for SIL 1 loops (full FMEDA report available).

APPLICATIONS

- Open channel flow flumes and weirs.
- Paint, ink and solvent tanks.
- Chemical storage.
- Thick and viscous media.
- Batch and day tanks.
- Sumps.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE		•						
cFMus						•	•	
Inmetro	•	•						
SIL	SIL 1 (1oo1)							

Other approvals are available, consult factory for more details

ECHOTEL® 335

Ultrasonic non-contact transmitter for level, volume or open channel flow

DESCRIPTION

Echotel® 335 is an integral mount, high performance ultrasonic non-contact transmitter for liquid level, volume and open channel flow measurement.

The electronics are housed in a dual compartment housing seperating field wiring from user interface electronics.

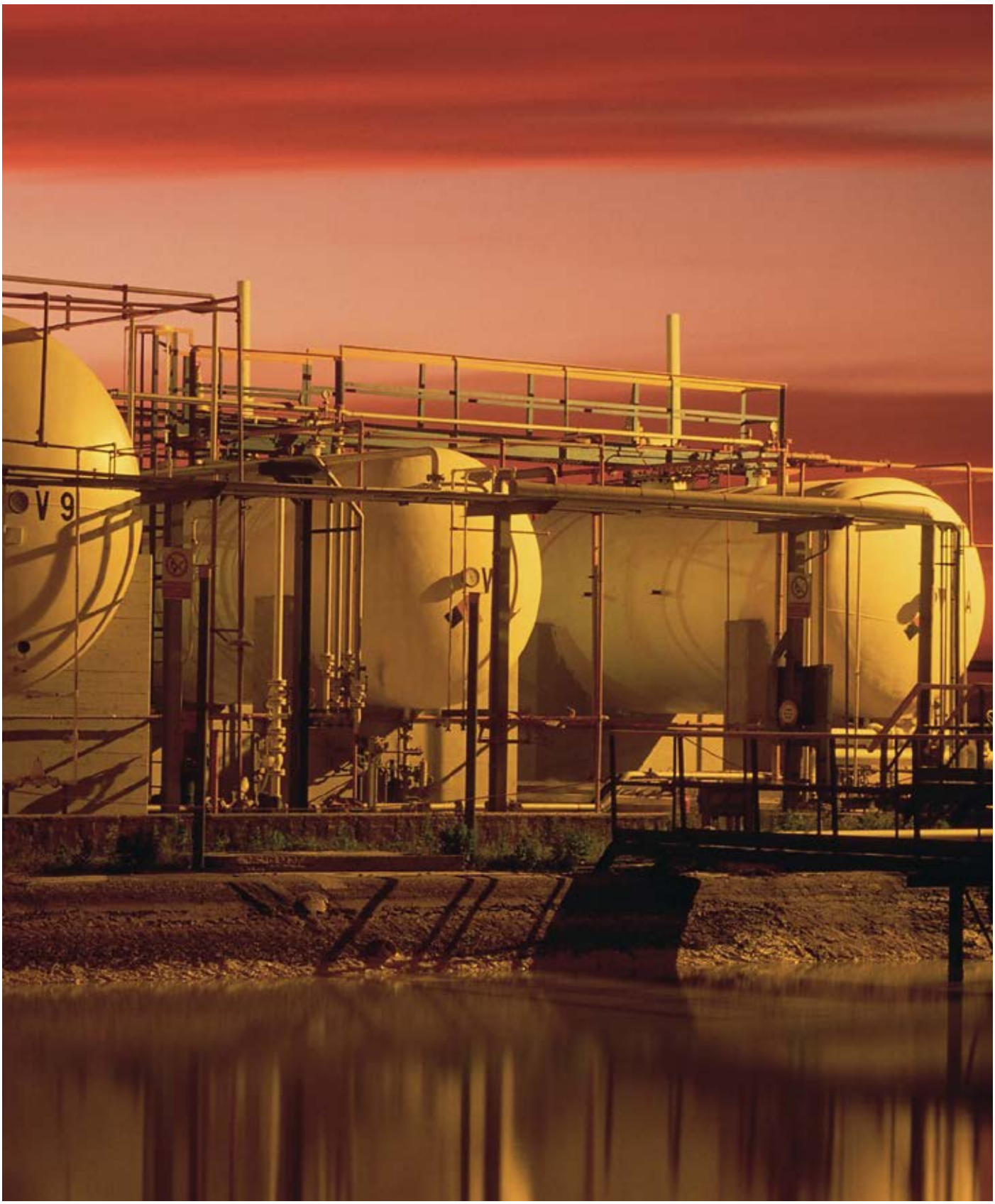
Advanced digital signal processing routines enable the 335 to perform in applications involving in-tank obstructions, light foam and agitation.

FEATURES

- Fast and easy calibration via 4 and 20 mA magnetic touch points.
- LED indication for
  - echo validity
  - relay status (energised/de-energised).
- Plug in custom / 6 digit display module (optional)
  - for easy set up
  - with bar graph display for liquid level % or echo strength.
- Process temperature from -30 °C to +90 °C (-22 °F to +195 °F).
- IP 67, dual compartment (field wiring / user interface electronics) in cast aluminium.
- Signal output: linearised 4-20 mA and separate relay for level alarm or echo loss tracking.
- 2 separate totalisers for flow:
  - daily resettable
  - continuous totaliser.
- Max level range: 8 m (26 ft).

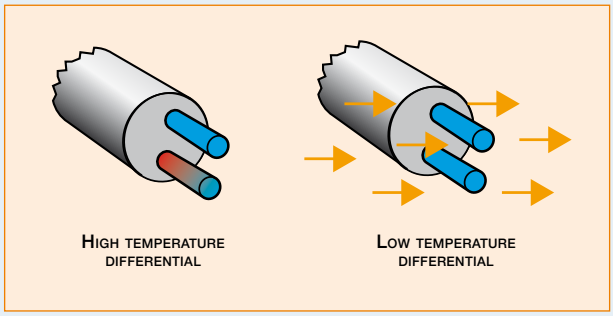
APPLICATIONS

- Water and waste water: tank - open channel flow measurement.
- Paper and pulp.
- Paint, ink and solvent tanks.
- General industry.
- Oil and chemical storage.
- Thick and viscous media.
- Food and beverage.
- Batch and day tanks.



THERMAL DISPERSION

The thermal switches are based on heat transfer. One sensor is at the process temperature and the other is being heated by a constant power. As the flow rate inc eases, the temperature difference between the sensors decreases. A set point is established so when that specific te - perature difference is reached the relay changes state. This can be on either increasing or decreasing flow or flow/n flo . When used in a level or interface application it is primarily the thermal conductivity of the fluid that will p ovide the difference in heat transfer.



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THERMATEL® TG1/TG2

Thermal dispersion switch

DESCRIPTION

Thermatel® TG1/TG2 switches consist of electronics in a DIN rail housing and a remote sensor with aluminium or stainless steel sensor housing (max 500 m (1640 ft) away from electronics).

TG1/TG2 switches can easily be adjusted to detect flow (gases and liquids), level or liquid-liquid interface. Both units are 2-wire 24 V DC powered and intrinsically safe approved.

TG1 offers standard LED flow indication, TG2 offers LED flow indication per NAMUR NE 44.

FEATURES

- Easy field calibration – pre-calibration from factory on request.
- Variable flow or flow / no flow detection of gases and liquids.
- Excellent low flow sensitivity.
- Continuous diagnostics detect sensor fault.
- Continuous monitoring of flow rate versus setpoint via LED.
- mA output provides repeatable indication of flow rate and fault detection.
- Optional retractable fitting for dismantling under process conditions.
- Unique spherical tip design option ideal for liquids or high viscosity applications.
- Process conditions up to +450 °C (+850 °F) and 413 bar (6000 psi).
- Suited for SIL1 and SIL2 loops (full FMEDA report available).

APPLICATIONS

Pump protection, low or high flow indication, high viscosity level, high temperature/pressure, interface detection.

MEDIA: All types of gases and liquids.

VESSELS: Pipe sizes down to 1/4". Max sensor length up to 3,3 m (10,8 ft). Can be installed at any angle vertically/horizontally.

CONDITIONS: Can be used on conductive and non conductive media, very light density to heavy viscous media. Can be set to ignore foam, aeration, turbulence, and cavitation.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX		•						
EAC (GOST)		•						
SIL	SIL 1 (1oo1)							

Other approvals are available, consult factory for more details

THERMATEL® TD1/TD2
Thermal dispersion switch

DESCRIPTION

Thermatel® TD1/TD2 switches can easily be adjusted to detect flow (gases and liquids), level or liquid-liquid interface. TD1 is a line powered 24 V DC unit with integral electronics and a built-in DPDT relay. TD2 is either V DC or V AC line powered, has integral or remote electronics and offers additional LED indication, time delay and mA output for diagnostics and trending.

With continuous diagnostics, automatic temperature compensation, narrow hysteresis and fast response time, TD1/TD2 bring you the latest in thermal dispersion technology.

FEATURES

- Easy field calibration – pre-calibration from factory on request.
- Variable flow or flow / no flow detection of gases and liquids.
- Excellent low flow sensitivity.
- Automatic temperature compensation for repeatable alarm under varying process temperatures.
- Continuous diagnostics detect sensor fault.
- Continuous monitoring of flow rate versus setpoint via LED (TD2).
- mA output provides repeatable indication of flow rate and fault detection (TD2).
- Set point / alarm can be measured over test points (TD2).
- Optional retractable fitting for dismantling under process conditions.
- Unique spherical tip design option ideal for liquids or high viscosity applications.
- Process conditions up to +450 °C (+850 °F) and 413 bar (6000 psi).
- Integral or remote electronics up to 150 m (500 ft).
- Suited for SIL1 and SIL2 loops (full FMEDA report available).

APPLICATIONS

Pump protection, low or high flow indication, high viscosity level, high temperature/pressure, interface detection.

MEDIA: All types of gases and liquids.

VESSELS: Pipe sizes down to 1/4". Max sensor length up to 3,3 m (10,8 ft). Can be installed at any angle vertically/horizontally, flanged, threaded or with compression fitting with or without hot or cold tap.

CONDITIONS: Can be used on conductive and non conductive media, very light density to heavy viscous media. Can be set to ignore foam, aeration, turbulence, and cavitation.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•							Ex d+ib
CCOE	•							
CSA					•		•	
FM					•		•	
EAC (GOST)	•							
IEC	•							Ex d+ib
Inmetro	•							Ex d+ib
Korea	•							
SIL	SIL 1 (1oo1)							

Other approvals are available, consult factory for more details

THERMATEL® TD2

Thermal dispersion switch for hygienic use

BPE

DESCRIPTION

Thermatel® TD2 switches can easily be adjusted to detect flow (gases and liquids), level or liquid-liquid interface. TD2 is either V DC or V AC line powered and offers additional LED indication, time delay and mA output for diagnostics and trending.

The unit has both 3A and EHEDG approval for use in hygienic applications.

FEATURES

- Easy field calibration – pre-calibration from factory on request.
- Variable flow or flow / no flow detection of gases and liquids.
- Excellent low flow sensitivity.
- Automatic temperature compensation for repeatable alarm under varying process temperatures.
- Continuous diagnostics detect sensor fault.
- Continuous monitoring of flow rate versus setpoint via LED.
- mA output provides repeatable indication of flow rate and fault detection.
- Set point / alarm can be measured over test points.
- Suited for SIL1 loops (full FMEDA report available).
- Hycienic process connections.

APPLICATIONS

Pump protection, low or high flow indication, high viscosity level, high temperature/pressure, interface detection.

MEDIA: All types of gases and liquids.

VESSELS: Max sensor length up to 3,3 m (10,8 ft). Can be installed at any angle vertically/horizontally.

CONDITIONS: Can be used on conductive and non conductive media, very light density to heavy viscous media. Can be set to ignore foam, aeration, turbulence, and cavitation.

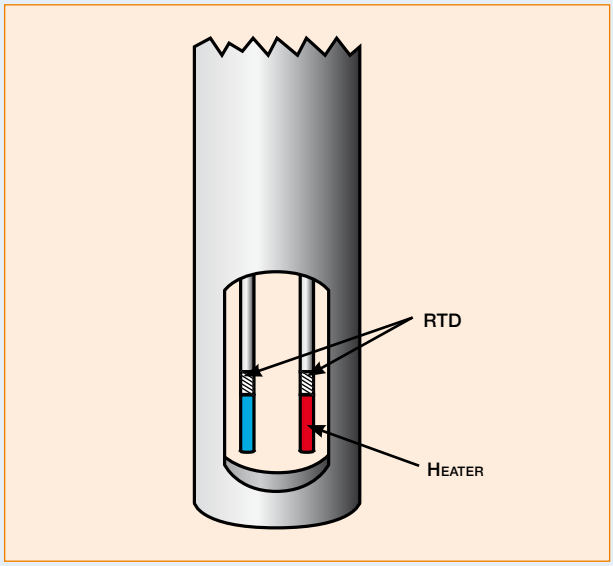
AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
SIL	SIL 1 (1oo1)							
TNO	Hygienic Machinery Directive 98/37/EC annex 1, section 2,1 EN 1672 part 2, Hygienic requirements EHEDG doc. 2 (second edit. March 2000) and doc. 8 (July 1993)							

Other approvals are available, consult factory for more details

THERMAL DISPERSION
Mass Flow Measurement

Thermal flow meters a e primarily used in air and gas flow measu ement applications. The meters consist of a transmitter and probe with temperature sensors (RTDs) located in the pins at the bottom of the probe. One sensor measures the process temperature and the other sensor is heated to a specific temperatu e above this. As the flow rate increases heat gets taken away from the heated sensor. Some manufacturers use a variable power operation to keep the temperature difference constant, while others keep the power constant and measure the temperature difference. The Magnetrol® Model TA2 measures the power it takes to maintain a constant temperature difference between the sensors. This relationship between power and mass flow rate is established during calibration



flo .magnetrol.com

THERMATEL®
ENHANCED MODEL TA2
Thermal mass flow meter

DESCRIPTION

Enhanced Model TA2 Thermal Mass Flow Meter provides reliable mass measurement for air and gas flow applications. The powerful, yet easy to use, electronics are contained in a compact flameproof enclosure. TA2 is available with both insertion probes as well as flow body design for smaller pipe sizes. TA2 offers excellent performance at an exceptional value.

FEATURES

- Direct mass flow measurement of air and gases.
- No need for temperature/pressure correction.
- High turndown ratio 100:1.
- Excellent low flow sensitivity.
- Low pressure drop.
- NIST traceable calibrations.
- Flow, temperature and totalised flow available over HART®.
- Advanced diagnostics check condition of probe, electronics, and wiring.
- Rotatable plug-in display module provides display of flow rate, temperature, totalised flow, plus diagnostic messages.
- Process temperatures up to +205 °C (+400 °F).
- Pressure rating up to 103 bar (1500 psi) dependent upon process connections.
- Probe can be field replaced.
- Calibration verification in the field.
- Optional: - retractable probe assembly or valve with compression fitting
  - flow body for 1/2" to 4" pipe sizes
  - flow conditioning plate for flow bodies 1 1/2" and higher.
- Accepts both AC and DC power input.
- Optional pulse output plus second mA output which can be used for temperature or different flow range (passive output only).
- 2-line x 16 characters backlit display with 4- button keypad for ease of configuration.
- Calibration for two different gases.
- Auto switching for extended turndown.
- Language selections of English, German, French, Spanish and Russian.
- Rotatable housing in aluminium or stainless steel.
- Suited for SIL 1 and SIL 2 loops (full FMEDA report available).

APPLICATIONS

Compressed air, combustion air, aeration air, natural gas, flare gas, digester/biogas/landfill gas, hydrogen cooling, nitrogen tank blanketing.

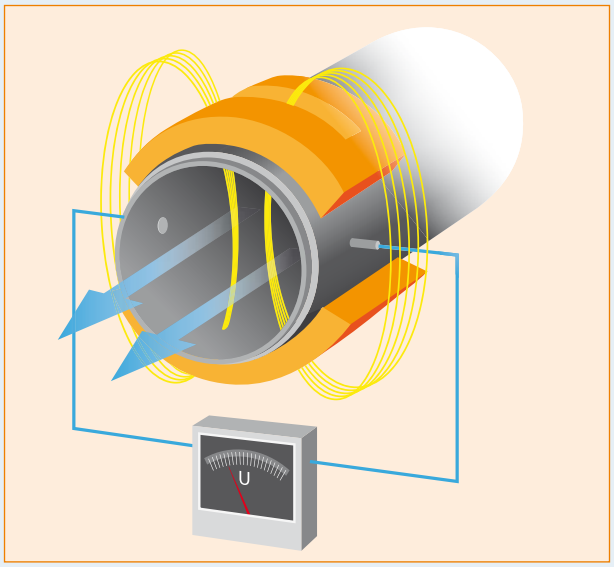
AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•							Ex d+ib
CCOE	•							
cFMus					•		•	
EAC (GOST)	•							Metrology
IEC	•							
Inmetro	•							
Korea	•							
SIL	SIL 1 (1oo1)							

Other approvals are available, consult factory for more details

ELECTROMAGNETIC FLOW METER

The function of an electromagnetic flow meter is based on Faraday's law of induction. The sensor consists of a non-magnetic and non-conductive tube with two embedded measuring electrodes. To create an alternating magnetic field, two coils a e fitted onto the tube in parallel with the plane defined by the active parts of the measuring ele - trodes. If a conductive liquid flows ac oss the magnetic field, a voltage will appear on the measuring elect odes proportional to the flow velocity and the conductor len th.



water.magnetrol.com
polaris.magnetrol.com

POLARIS®
Electromagnetic flow meter

DESCRIPTION

The electromagnetic flow meter consists of a sensor through which the measured liquid flows and an electronic unit where the low-level signal from the sensor is modified to a standardized form suitable for further processing in various industrial electronic devices.

The output signal is proportional to the volumetric flow rate of the measured liquid. The only factor limiting the application of electromagnetic flow meters is the requirement that the measured liquid shall be conductive and non-magnetic.

The electromagnetic flow meter can be designed either as an integral device or with the sensor separated from the associated electronic unit. In the former case, the electronic unit is fitted directly onto the sensor, in the latter case it is connected to the sensor by a remote cable.

The sensor design shall take into consideration the type of the measured liquid and its operational parameters. To facilitate fitting into the liquid piping, the sensor can be provided with end flanges or as a wafer style design.

FEATURES

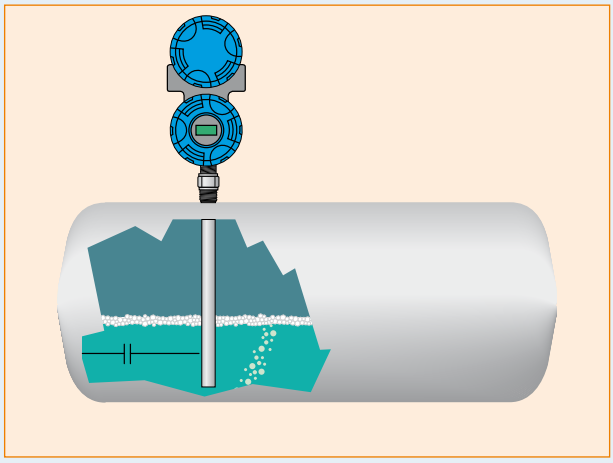
- 4-20 mA, pulse, and alarm outputs.
- Liquid conductivity down to 5 µS/cm.
- Forward and reverse flow indication.
- Multiple liner and electrode options.
- HART protocol for use with PACTware™.
- Flanged or wafer style sensors.

APPLICATIONS

Conductive liquids:
- water
- water based liquids
- sludge flows.

RF CAPACITANCE

The liquid acts as an isolator between two conductors (probe and tank wall). When level rises, there is more gain of capacity into an analog or digital signal.



HART COMMUNICATION PROTOCOL

KOTRON® 805
Smart RF level transmitter

DESCRIPTION

Kotron® series 805 is an economical but "full function" 2-wire loop-powered 24 V DC, smart RF transmitter. The microprocessor based electronics allow the user to calibrate the 805 with only one small level change. The electronics are housed in an ergonomical dual compartment housing which is directly mounted on top of the probe.

FEATURES

- Transmitter with local keypad/display.
- Calibration using HART®, or locally via a 2-line x 8 characters display and a 3-button keypad.
- Continuous local display of level, % and loop signal.
- Fault identification via FAULT message on display.
- Other Features:
  - Ergonomical - 45° angle, dual compartment housing isolates terminal board from electronics.
  - Transmitter head can be removed from probe without depressurising the vessel.
  - Process temperature max +540 °C at 35 bar (+1000 °F at 500 psi).
  - Process pressure max 345 bar at +40 °C (5000 psi at +100 °F).
  - Compatible with over 50 application oriented KOTRON® probes (see bulletin BE 50-125).

APPLICATIONS

- Hydrocarbons & solvents.
- Corrosives, acids and caustics.
- Powders & granulars.
- High temperature/pressure liquids.
- Interface.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX		•						
CSA					•	•	•	
FM						•	•	

Other approvals are available, consult factory for more details

KOTRON® 82
Level transmitter

DESCRIPTION

Kotron® 82 2-Wire RF capacitance transmitter is one of the most cost effective level transmitters available today.

Compact in size, it employs state of the art technology for a stable, accurate signal in a wide range of materials.

FEATURES

- Uses state of the art technology to provide a stable, more accurate signal.
- 4-20 mA isolated output signal.
- Utilises a 24 V DC current loop for power source and signal transmission.
- Input voltage of 14 to 40 V DC at transmitter terminals.
- Potted electronics are vibration resistant, protect electronics from the environment and allow easy wiring.
- Has integral metering points to allow the local measurement of 4-20 mA loop current without breaking the two-wire circuit loop.
- Power indicator LED varies in brightness with level changes.
- Available with a full range of rigid and flexible sensing probes to 345 bar (5000 psi) and +540 °C (+1000 °F).

APPLICATIONS

- Clean or dirty liquids.
- Viscous liquids.
- Light slurries.
- Corrosive liquids.
- High temperature liquids.
- Chemicals.
- Hydrocarbons & solvents.
- Food & beverage.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
CSA					•	•	•	
FM						•	•	
EAC (GOST)		•						

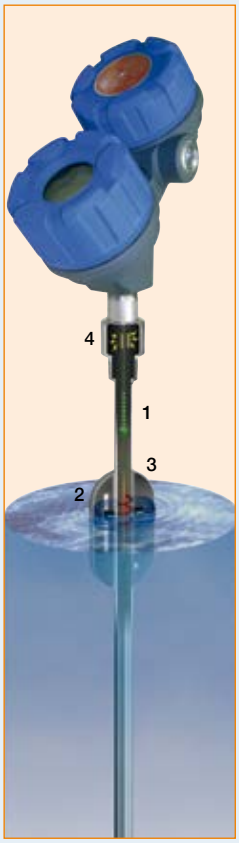
Other approvals are available, consult factory for more details

MAGNETOSTRICTIVE

ORION INSTRUMENTS
A Magnetrol Company

Jupiter® magnetostrictive transmitter utilises the effect of a magnetic field on a magnetostrictive wi e as the basis for operation of the instrument. The primary components are the probe assembly containing the wire and the electronics assembly.

1. A low energy pulse which is generated by the electronics travels the length of the magnetostrictive wire.
2. A return signal is generated from the precise location where the magnetic field of the float intersects the wi e.
3. Interaction between the magnetic field, electrical pulse and magn - tostrictive wire cause a slight mechanical disturbance in the wire that travels back up the probe at the speed of sound.
4. A timer precisely measures the elapsed time between the generation of the pulse and the return of the mechanical or acoustic signal. This is detected by the acoustic sensor located below the electronics housing. The software is set up to measure the time-of-flight data and to display and convert to level and/or liquid-liquid interface measurement.



SIL SAFETY INTEGRITY LEVEL
Ex
HART COMMUNICATION PROTOCOL
AMS
PACTware
FDT Connected
FOUNDATION

JUPITER® JM4
Magnetostrictive level transmitter

DESCRIPTION

Jupiter® liquid level transmitter is a loop-powered 24 V DC liquid-level transmitter and is available as a direct insertion transmitter or as an external mounted transmitter onto a Magnetic Level Indicator. The unit can be designed for liquid level and/or liquid-liquid interface measurement.

The innovative enclosure is a first in the industry, orienting dual compartments (wiring and electronics) in the same plane and angled to maximize ease of wiring, configuration, set-up and data display.

The high safety level of JUPITER is demonstrated by a Safe Failure Fraction > 90 %.

FEATURES

- High precision and repeatable level measurement:
  - accuracy up to ± 1,27 mm (0.05")
  - repeatability of ± 0,36 mm (0.014").
- Easy bench configuration – no need for level simulation.
- Auto-configuration option – configuration settings contained within probe.
- Rotatable housing can be dismantled without depressurising the vessel via "Quick connect/disconnect" probe coupling.
- 2-wire loop powered intrinsically safe level transmitter.
- Dual compartment with separate housing for wiring and electronics.
- 4-button user interface and graphical LCD display provide enhanced depth of data, indicating on-screen waveforms and troubleshooting tips.
- Process temperature up to +425 °C (+800 °F).
- Process pressure up to 207 bar (3000 psi)
- Probe lengths up to 10,7 m (35 ft).
- Float failure reporting.
- IP 67 Enclosure Rating.
- Suited for SIL 1 or SIL 2 loops (full FMEDA report available).

APPLICATIONS

MEDIA: Highly recommended for use in liquids with enhanced foam development. Interface measurement where the upper liquid layer has a higher dielectric than the lower liquid layer.

CONDITIONS: Suited for use in a turbulent liquid environment as the float remains in contact with the liquid surface whilst emitting its signal.

AGENCY APPROVALS

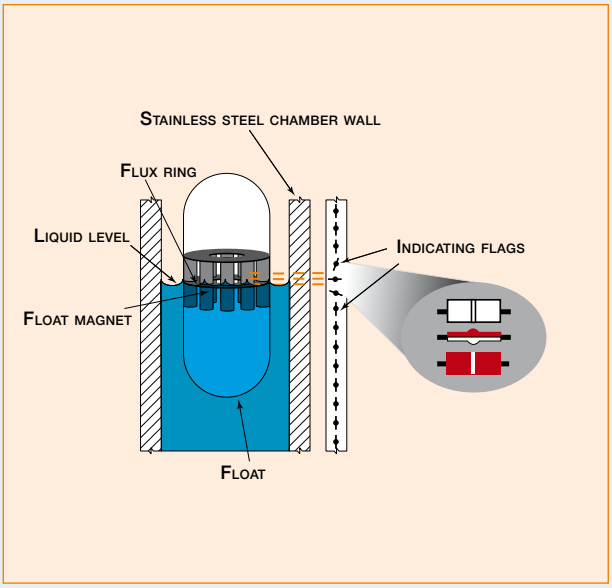
	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•	•					
CCOE								
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)	•	•						Metrology
IEC	•	•	•					
Inmetro	•	•						
Korea		•						
NEPSI								CPA
SIL	SIL 1/2 (1oo1)							

Other approvals are available, consult factory for more details

MAGNETIC LEVEL INDICATORS

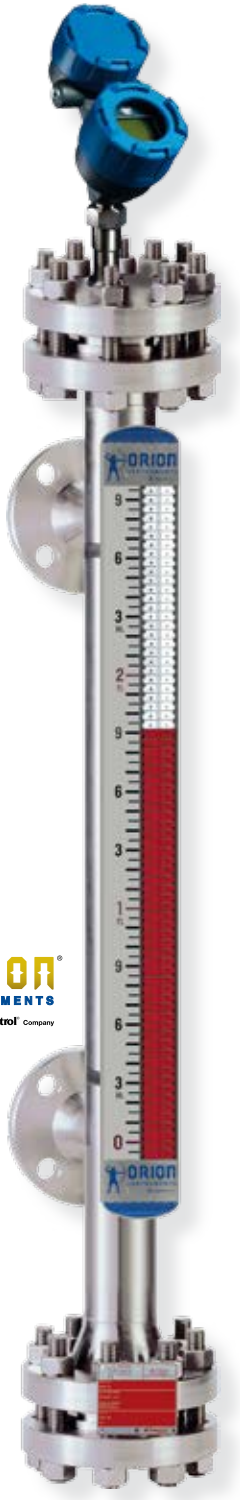
ORION® INSTRUMENTS
A Magnetrol® Company

The Magnetic Level Indicator (MLI) consists of a sealed bypass cage, a float containing a magnet and a visual indicator rail with bi-coloured flags that individually co - tain a magnet. The indicator rail is external mount on the cage and its flags a e magnetically coupled/aligned with the magnet of the float. As the level changes, the float wil follow and its magnet will attract the magnets in the flags. This will cause the flags to otate showing their opposite coloured side. The same electro-magnetic coupling will activate/deactivate switches or change the output of an externally clamped-on magnetostrictive transmitter.



AURORA®

Guided wave radar level transmitter and magnetic level indicator



ORION INSTRUMENTS
A Magnetrol Company

DESCRIPTION

Aurora® combines the operation of a conventional float operated magnetic level indicator with the leading edge technology of Guided Wave Radar. The result is a true level measurement redundancy in a single 3" or 4" chamber design. Eclipse® Guided Wave Radar is a 2-wire loop powered 24 V DC liquid level transmitter utilising Time Domain Reflectometry technology (TDR) to perform level measurement independent from media characteristics and process conditions. AURORA is a completely self-contained unit for side mounting to a tank or vessel with threaded or flanged pipe connections.

FEATURES

- Complete redundant system whereby the measuring results of ECLIPSE can be continuously checked against the level indication of the Magnetic Level Indicator.
- Pro-active maintenance can be planned ahead of time based upon the comparison of the measuring results of the two systems.
- No calibration required on either measuring system.
- 2-wire loop powered intrinsically safe level transmitter.
- HART®, AMS®, Foundation Fieldbus™ and PACT*ware*™ communication protocol.
- Up to 5,7 m (224") measuring range.
- Up to 103 bar (1500 psi) – optional up to 310 bar (4500 psi).
- Up to +450 °C (+850 °F) process temperature for non-condensing applications (depending rail material).
- Up to 155 bar @ +345 °C (2250 psi @ +650 °F) for saturated steam applications.
- Suited for SIL 1 and SIL 2 loops (full FMEDA report available for ECLIPSE transmitter) – optional SIL 2/3.
- ECLIPSE 705 transmitter SIL 3 certified (EXIDA certificate available).
- Several cage designs are available, consult factory for more details.

APPLICATIONS

MEDIA: Clean liquids; hydrocarbons to water-based media (dielectric 1.4-100).

INTERFACE: Consult factory.

VESSELS: Most process or storage vessels up to rated probe temperature and pressure.

CONDITIONS: All level measurement and control applications including process conditions exhibiting visible vapours, foam, surface agitation, bubbling or boiling, high fill/empty rates, low level and varying dielectric media.

AGENCY APPROVALS (for ECLIPSE 705 GWR)

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•	•	•				
CCOE	•	•						
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)	•	•						Metrology
IEC	•	•						
Inmetro	•	•						
Korea	•	•						
NEPSI								CPA

Marine	Lloyd's Register of Shipping (LRS)
SIL	SIL 1/2 (1oo1)
Steam Drum	Lloyds EN 12952-11 (water tube boilers) Lloyds EN 12953-9 (shell boilers)
TÜV	WHG § 63, overfill prevention

Other approvals are available, consult factory for more details

VECTOR™
Magnetic level indicators

DESCRIPTION

Vector™ is a rugged, reliable and cost-effective Magnetic Level Indicator (MLI). Suitable for a variety of installations, VECTOR has many basic features and is precision-engineered and manufactured to ensure a long service life.

MLIs are widely used to replace high-maintenance sight and gauge class indicators and are increasingly used in new applications. Optional switches and transmitters are available to provide various output signals for level control.

FEATURES

- Rugged, industrial grade construction.
- Rail can be rotated to obtain better viewing position.
- Immediate and accurate response to level changes.
- Max process pressure of the float 85 bar (1230 psi).
- Max process temp. +260 °C (+500 °F).
- Min process temp. -40 °C (-40 °F).
- Measuring range up to 5,5 m (18 ft).
- Standard S.G. range from 0,54 - 1,50 kg/dm^3.
- Floats are not vented nor gas filled.
- Options:
  - scale in cm or tailor made
  - reed type bi-stable switches
  - reed chain transmitter with 4-20 mA output.

APPLICATIONS

MEDIA: Clean liquids.

VESSELS: Most process and storage tanks up to rated operating pressure and process temperature.

FUNCTION: Continuous liquid level or liquid-liquid interface indication.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX								Ex c
EAC (GOST)								Ex c

ATLAS™
Magnetic Level Indicator

DESCRIPTION

Atlas™ is our standard high-performance magnetic level indicator. ATLAS is a single chamber design with either a 2", 2 ½", or 3" chamber diameter, as required by the application. There are twelve basic configuration styles including top mount models.

ATLAS MLIs are produced in a wide range of materials, including exotic alloys and plastics. We also offer the most complete selection of process connection types and sizes in the industry.

ATLAS can be equipped with a variety of level transmitters and switches as well as flag and shuttle indicators with or without stainless steel scales. This enables ATLAS to be a complete level and monitoring control.

ATLAS may be equipped with the external mount Jupiter®, magnetostrictive transmitter, or with an Eclipse® Guided Wave radar in an enlarged cage.

FEATURES

- Precision manufactured float with multiple magnets and flux ring for an optimum Gauss rating.
- Viewing window made of shatter-resistant polycarbonate.
- Viewing window filled with dry nitrogen gas to eliminate condensation and allow for maintained visibility.
- Double O-ring seal prevents contaminants from entering the viewing window.
- Flags are designed with mechanical stop for stable indication of fast varying level changes.
- Shuttle followers for level and interface indication.
- Stainless steel flags in aluminium or stainless steel (optional) indication rail.
- 1/2" NPT vent and drain (other options available).
- Max hydrotest pressure of the float: 62 bar (900 psi) - higher pressure (up to 310 bar (4500 psi)) on request.
- Min operating process temperature: -50 °C (-60 °F) standard, down to -196 °C (-320 °F) on request.
- Max operating process temperature up to + 540 °C (up to +1000 °F) with factory supplied insulation.
- S.G. range as low as 0,49 kg/dm^3 (lower S.G. on request).
- Bottom and top spring protection of the float avoids float damage during transport, maintenance and surging/ flashing conditions.
- Options:
  - high and low temperature options
  - stainless steel scale for level or volume
  - JUPITER magnetostrictive transmitter.
- Several cage designs are available, consult factory for more details.

APPLICATIONS

MEDIA: Clean liquids with a S.G. ≥ 0,49 kg/dm^3 incl. aggressive, toxic and flammable liquids / liquified gases.

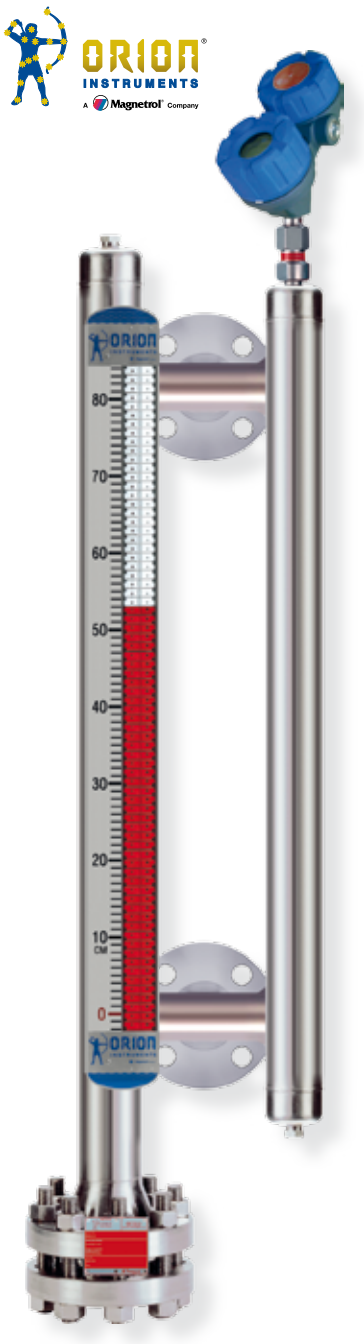
VESSELS: Most process and storage tanks up to rated operating pressure and process temperature.

FUNCTION: Continuous liquid level or liquid-liquid interface indication.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX								Ex c
EAC (GOST)								Ex c
Marine	Lloyd's Register of Shipping (LRS)							

GEMINI™
Magnetic Level Indicator



DESCRIPTION

This twin chamber design is unique to the Magnetic level gauge industry. Countless unique configuration styles are available with Gemini™. It can be produced in the same metal material selections as Atlas™.

The second chamber facilitates the installation of any of a wide selection of transmitters to provide continuous level monitoring in addition to the indication provided by the primary chamber. Eclipse® guided wave radar or direct insertion Jupiter® magnetostrictive level transmitters can be mounted in the secondary chamber to provide totally redundant indication with continuous level output. The primary chamber, which houses the float, can be fitted with clamp-on switches or transmitters for additional level control.

FEATURES

- Precision manufactured float with multiple magnets and flux ring for an optimum Gauss rating.
- Viewing window made of shatter-resistant polycarbonate.
- Viewing window filled with dry nitrogen gas to eliminate condensation and allow for maintained visibility.
- Double O-ring seal prevents contaminants from entering the viewing window.
- Flags are designed with mechanical stop for stable indication of fast varying level changes.
- Shuttle followers for level and interface indication.
- Stainless steel flags in aluminium or stainless steel (optional) indication rail.
- 1/2" NPT vent and drain.
- Max hydrotest pressure of the float: 62 bar (900 psi) - higher pressure (up to 310 bar (4500 psi)) on request.
- Min operating process temperature: -50 °C (-60 °F) standard, down to -196 °C (-320 °F) on request.
- Max operating process temperature up to + 540 °C (up to +1000 °F) with factory supplied insulation.
- S.G. range as low as 0, 49 kg/dm^3 (lower S.G. on request).
- Bottom and top spring protection of the float avoids float damage during transport, maintenance and surging/ flashing conditions.
- Options:
  - Eclipse® guided wave radar transmitter.
  - Jupiter® magnetostrictive transmitter.
  - E3 Modulevel® displacer transmitter.
  - Kotron® RF capacitance transmitter.
  - Valves for isolation.
  - Display options: level, volume, or percent. Custom scale and dual scale options available.
  - High and low temperature options.
- Several cage designs are available, consult factory for more details.

APPLICATIONS

MEDIA: Clean liquids with a S.G. ≥ 0,49 kg/dm^3 incl. aggressive, toxic and flammable liquids / liquified gases.

VESSELS: Most process and storage tanks up to rated operating pressure and process temperature.

FUNCTION: Continuous liquid level or liquid-liquid interface indication.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
EAC (GOST)								Ex c

OPTIX™
LED visual Indicator

DESCRIPTION

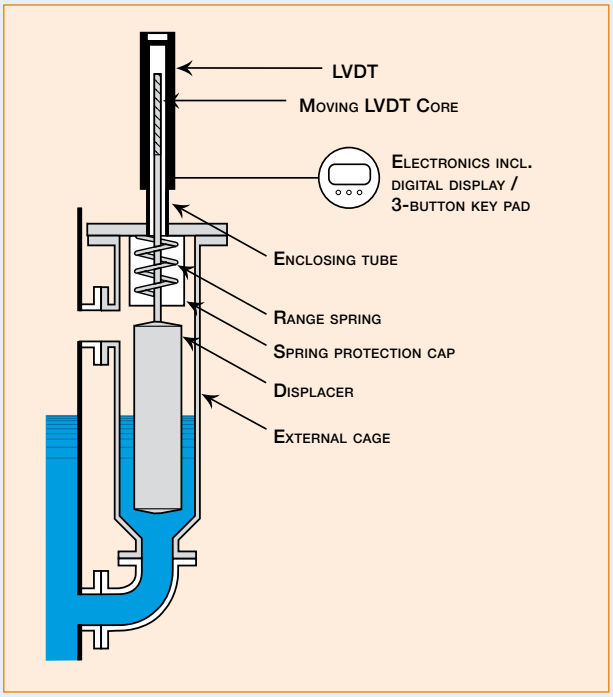
The new Optix™ LED indicator is engineered to provide local illuminated visual indication. This two-wire device can be installed on any Magnetic Level Indicator, greatly enhancing low-light performance. OPTIX can be powered using a separate, dedicated 24 V DC power source, or as part of an existing two-wire 4-20 mA loop without interfering with the analog output of an existing device. A DC-powered solution eliminates the need for costly copper wiring normally required with competing AC-powered LED-based products.

FEATURES

- Scales available: meter/cm, feet/inches, percent, and custom volumetric.
- Construction: anodized aluminum enclosure.
- Est. LED Lifespan: 100.000 hours.

DISPLACER TRANSMITTER

The buoyancy force works on the displacer which will vertically move in (increasing liquid level) and out (decreasing liquid level) the linear differential transformer (LVDT). Due to this movement voltages are induced in the secondary windings of the LVDT. These signals are then processed in the electronic circuitry and used to control the output signal.



e3modulevel.magnetrol.com

SIL Ex HART COMMUNICATION PROTOCOL AMS PACTware FOUNDATION

E3 MODULEVEL®
Displacer operated level transmitter

DESCRIPTION

E3 Modulevel® is a 2-wire, loop-powered level transmitters utilising the buoyancy principle to detect and convert liquid level changes into a stable output signal.

The linkage between the level sensing element and output electronics greatly simplifies mechanical design and construction. The in-line vertical design of the transmitter reduces instrument weight and the effects of process vibration on electronic circuitry components while simplifying installation.

FEATURES

Operation functions include:
- interface measurement and detection
- continuous level measurement
- density measurement.

2-line x 8 characters display LCD and 3-button keypad.

Easy bench configuration. No need for level simulation.

2-wire loop powered intrinsically safe level transmitter.

360° rotatable housing can be dismantled without depressurising the vessel.

Special options, materials and custom engineered features.

SIL 2 / SIL 3 capable certified.

Several cage designs are available, consult factory for more details.

APPLICATIONS

MEDIA: Liquids with a S.G. as low as 0,23 and up to 2,2 kg/dm^3 and interfaces with a minimum density difference of 0,10 kg/dm^3.

VESSELS: Most process vessels up to +450 °C (+850 °F) for non-condensing and +425 °C (+800 °F) for condensing process temperature and pressures up to 355 bar (5150 psi) or storage vessels e.g:

- feedwater heaters
- condensate drip pots
- scrubbers
- separators
- receivers
- flash tanks
- knock-out drums
- boilers.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE	•							
CSA					•	•	•	
FM					•	•	•	
EAC (GOST)	•	•						Metrology
IEC	•	•						
Inmetro	•	•						
Korea		•						
NEPSI								CPA

Marine	Lloyd's Register of Shipping (LRS)
SIL	SIL 2 (1oo1)

Other approvals are available, consult factory for more details

PNEUMATIC MODULEVEL®

Liquid level control

DESCRIPTION

Pneumatic Modulevel® controls are displacement actuated level sensors. They provide output signals in direct proportion to changes in liquid level.

Simple, modular design and proven magnetic coupling make MODULEVEL controls versatile, highly stable, vibration resistant and adaptable to extremes of temperature and pressure.

FEATURES

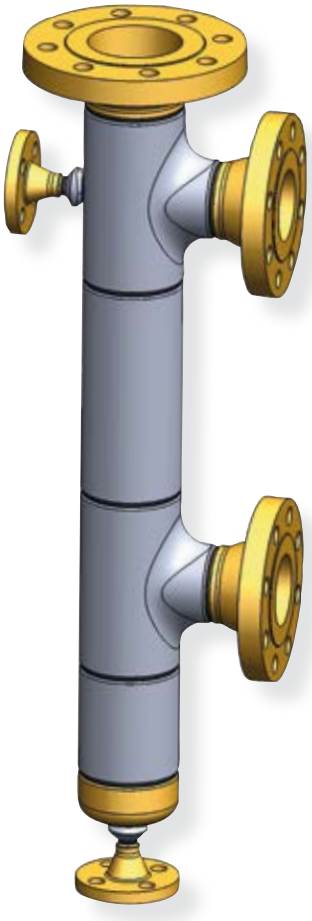
- Standard models handle service temperatures from -100 °C to +370 °C (-150 °F to +700 °F) and pressure to 294 bar (4265 psi).
- Stable output signal is unaffected by surface turbulence. Prevents control valve "hunting" and extends valve life.
- Controller head may be removed and bench calibrated without dismantling or even depressurising the tank.
- Accurate output signal provided over a wide specific gravity range.
- 316 SS displacer and trim.
- Easy field calibration without moving tank liquid level, reducing installation time and cost.
- Controller head rotates 360°, simplifies pneumatic piping hookup.
- Pilot relay provides a 4 to 1 amplification of pilot pressure signal to speed valve response.
- Built-in visual level indicator is independent of air supply.
- Optional pneumatic to current interface transducer for use in electronic control applications.
- Optional proportional plus integral control.
- Optional differential gap (on-off) control.
- Optional Hi-Lo electronic alarm signal provides inexpensive backup alarm.

APPLICATIONS

Pneumatic MODULEVEL liquid level controls are widely used in utility power generation, chemical and petroleum processing operations, such as:

- steam generator feedwater heater regulation
- fractionating column level transmitter
- ethanolamine level transmitter
- vent gas scrubber level control
- drip pot condensate level control
- flash tank level transmitter.

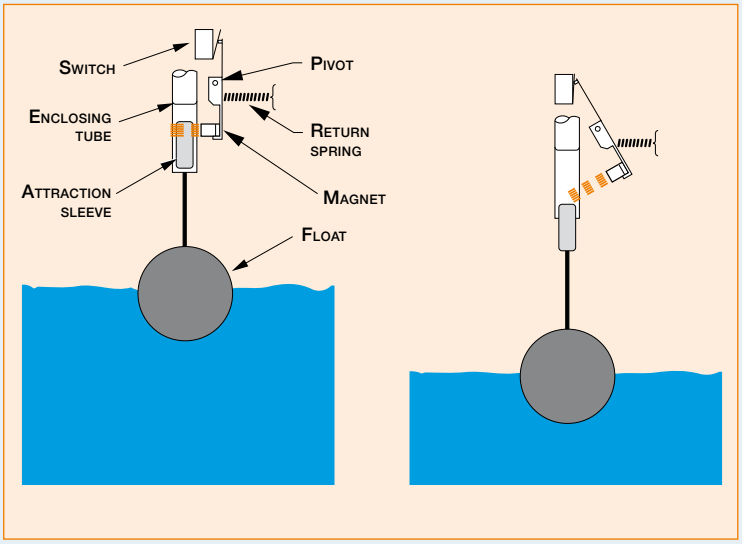
EXTERNAL CAGES
for electronic devices



Several devices such as Eclipse®, Modulevel®,… are mounted in (custom designed) external cages. Depending on process connection, process condition, customer specification,… several possibilities are possible. Below are some typical examples. Many other designs are possible, consult the factory for more details.

BUOYANCY

A permanent magnet is attached to a pivoted switch actuator. As the float/displacer rises following the liquid level, it raises the attraction sleeve into the field of the magnet, which then snaps against the non-magnetic enclosing tube, actuating the switch. The enclosing tube provides a static pressure boundary between the switch mechanism and the process. On a falling level, the float/displacer d - activates the switch.



T20 - T21
Liquid float level switch

DESCRIPTION

T20 and T21 units are user friendly, reliable float switches designed for top mounting to tanks or vessels. T20 units utilise a single switch mechanism and float. T21 units utilise two switch mechanisms and two separate floats when widely spaced actuating levels are required. T20 and T21 models are available for any type of open or closed vessel with either threaded or flanged type mounting and actuating depths up to 1219 mm (48 inches).

FEATURES

- Carbon or stainless steel process connection materials (other materials available on request).
- Flanged and threaded process connections.
- Process temperature up to +400 °C (+750 °F).
- Up to 2 switch levels (T21).
- S.G. as low as 0,60 kg/dm^3.
- Process pressure up to 41,3 bar (600 psi).
- Standard anti-corrosive protection.
- Optional:
  - NACE construction (MR-01-75)
  - interface calibration
  - special actuating levels
  - special tank connections
  - extreme temperature modifications
  - class 1, Group B explosion proof electrical enclosure
  - special exterior surface preparation and finish.
- Suited for SIL 2 loops (DPDT switch) (full FMEDA report available).

APPLICATIONS

- Day tanks.
- Condensate receivers.
- Fuel storage tanks.
- Cooling towers.
- Flash tanks.
- Interface.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE	•							
CSA					•			
FM					•			
EAC (GOST)	•	•						
IEC	•							
Inmetro	•							
Korea	•							
NEPSI		•						
Marine	Lloyd's Register of Shipping (LRS)							
SIL	SIL 2 (1oo1)							

Other approvals are available, consult factory for more details

A10/15 - B10/15 - C10/15
Liquid displacer level switch

DESCRIPTION

Magnetrol® displacement type level switches offer the industrial user a wide choice of alarm and control configurations. Each unit utilises a simple buoyancy principle and is well suited for simple or complex applications, such as foaming or surging liquids or agitated fluids, and usually costs less than other types of level switches.

FEATURES

- Narrow or wide level ranges achieved through multiple switch mechanism capability.
- Maximum process temperature: +260 °C (500 °F).
- Maximum process pressure: 55,1 bar (800 psi).
- S.G. as low as 0.4 kg/dm³.
- Displacers adjustable at any point along the suspension cable.
- Anti-surge design eliminates the possibility of switch short cycling.
- Standard 3 m (10 ft) of suspension cable, included for all models.
- Field adjustable set point and switch differential.
- Wide choice of displacer materials.
- Wide choice of housings and switch mechanisms
- Standard anti-corrosive protection.
- Optional:
  - NACE construction (MR-01-75)
  - proof-er® ground check
  - floating roof models
  - high pressure models
  - models for interface.
- Suited for SIL 2 loops (DPDT switch) (full FMEDA report available).

APPLICATIONS

Foaming or surging liquids – Paints – Agitated fluids – Varnishes – Sewage handling – Heavy oils – Dirty liquids – Liquids with solids

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE	•							
CSA					•			
FM					•			
EAC (GOST)	•	•						
IEC	•							
Inmetro	•							
Korea	•							
NEPSI		•						

Marine	Lloyd's Register of Shipping (LRS)
SIL	SIL 2 (1oo1)
TÜV	WHG § 63, overfill prevention

Other approvals are available, consult factory for more details

TUFFY® T3
Side mounting level control

DESCRIPTION

Tuffy® liquid level switches are float actuated devices designed for horizontal mounting in a tank or vessel through threaded or flanged pipe connections. The compact size allows for installation in small vessels, while its many features provide a variety of application uses. The single switch mechanism is available in SPDT or DPDT forms on units designed for adjustable, narrow or wide differential and interface service.

FEATURES

- Maximum process temperature: +400 °C (+750 °F).
- Minimum process temperature: -55 °C (-65 °F).
- Maximum process pressure: 181 bar (2630 psi).
- S.G. as low as 0.4 kg/dm^3.
- Wetted parts in 316/316L (1.4401/1.4404) or Hastelloy C (2.4819).
- Available as:
  - flanged
  - threaded
  - flanged or sealed cage mounted.
- Suited for SIL 2 loops (DPDT switch) (full FMEDA report available).

MODELS

- Narrow differential switch (for alarm functions):
  - standard pressure (up to 50 bar (720 psi))
  - high pressure (up to 150 bar (2160 psi)).
- Wide adjustable differential switch (for control functions).
- Interface switch (detection of interface level between liquids).
- External cages.
- Compact versions:
  - pneumatic narrow differential switch
  - electric narrow differential switch.

APPLICATIONS

- Sour service (NACE).
- High/low alarm.
- Single pump control.
- Day storage tanks.
- Corrosive processes.
- Process vessels.
- Boiler low water cut-off.
- Interface level.
- Installations in hazardous area.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CSA					•			
FM					•			
EAC (GOST)	•	•						
IEC	•							
NEPSI	•	•						
SIL	SIL 2 (1oo1)							
TÜV	WHG § 63, overfill prevention							

Other approvals are available, consult factory for more details

T62 - T64 - T67
Side mounting liquid float level switch

DESCRIPTION

Side mounting controls mount horizontally to any tank or vessel through a threaded or flanged pipe connection. Standard models are normally equipped with a single switch mechanism for high or low level alarm or control applications. Tandem models with two switch mechanisms are available for two level stage applications, providing the operating functions of two separate instruments such as high and low level alarm.

FEATURES

- Carbon or stainless steel body materials (other materials available on request).
- Flanged and threaded process connections.
- Process temperature up to +400 °C (+750 °F).
- Up to 2 switch levels (T67).
- S.G. as low as 0,40 kg/dm^3.
- Process pressure up to 82,7 bar (1200 psi).
- Field adjustable level differentials from 32 mm (1.25") up to 409 mm (16.12").
- Standard anti-corrosive protection.
- Optional:
  - NACE construction (MR-01-75)
  - interface calibration
  - special actuating levels
  - code compliance construction
  - special tank connections
  - extreme temperature modifications
  - Class 1, Group B explosion proof electrical enclosure
  - special exterior surface preparation and finish.

APPLICATIONS

- Foaming or surging liquids.
- Varnishes.
- Sewage handling.
- Heavy oils.
- Paints.
- Liquids with solids.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE	•							
CSA					•			
FM					•			
EAC (GOST)	•	•						
IEC	•							
Inmetro	•							
Korea	•							
NEPSI		•						

Other approvals are available, consult factory for more details

B40
High pressure / high temperature liquid float level switch

DESCRIPTION

B40 liquid level switch is specifically designed and constructed for high pressure, high temperature service conditions. These type level switches are completely self-contained units designed for side mounting to a tank or vessel with welded or flanged pipe connections.

FEATURES

- Cr Mo (Chrome - molybdenum), carbon steel or stainless steel welded float cages.
- Process temperature up to +540 °C (+1000 °F).
- Single switch level.
- S.G. as low as 0,65 kg/dm^3.
- Process pressure up to 207 bar @ +370 °C (3000 psi @ +700 °F).
- Standard anti-corrosive protection.
- Optional:
  - special tank connections
  - extreme temperature modifications
  - Class 1, Group B explosion proof electrical enclosure.
- Suited for SIL 2 loops (DPDT switch) (full FMEDA report available).

APPLICATIONS

- Accumulators.
- Flash tanks.
- Receivers.
- Knock-out drums.
- Flare pots.
- Storage tanks.
- Scrubbers.
- Separators.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•							
CCOE	•							
CSA					•			
FM					•			
EAC (GOST)	•	•						
IEC	•							
Inmetro	•							
Korea	•							
NEPSI		•						
SIL	SIL 2 (1oo1)							

Other approvals are available, consult factory for more details

EXTERNAL CAGE
Liquid float / displacer level switch

DESCRIPTION

External cage type level switches are completely self-contained units designed for side mounting to a tank or vessel with threaded or flanged pipe connections. These switches are engineered to customer specifications.

FEATURES

- Carbon or stainless steel welded float cages (other materials available on request).
- Process temperature up to +400 °C (+750 °F).
- Up to 3 switch levels.
- Standard anti-corrosive protection.
- Sealed/Flanged cages:
  - S.G. as low as 0,34 kg/dm^3
  - process pressure up to 138 bar (2000 psi) for floats
  - process pressure up to 345 bar (5000 psi) for displacers.
- Optional:
  - NACE construction (MR-01-75)
  - interface calibration
  - customised installation dimensions
  - special actuating levels
  - code compliance construction
  - special tank connections
  - extreme temperature modifications
  - Class 1, Group B explosion proof electrical enclosure
  - special exterior surface preparation and finish.
- Suited for SIL 2 loops (DPDT switch) (full FMEDA report available).

APPLICATIONS

Foaming or surging liquids – Paints – Agitated fluids – Varnishes – Sewage handling – Heavy oils – Dirty liquids – Liquids with solids.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE	•							
CSA					•			
FM					•			
EAC (GOST)	•	•						
IEC	•							
Inmetro	•							
Korea	•							
NEPSI		•						
Marine	Lloyd's Register of Shipping (LRS)							
SIL	SIL 2 (1oo1)							

Other approvals are available, consult factory for more details

EXTERNAL CAGES
for buoyancy devices

As with our electronic products our buoyancy products can also be mounted in (custom designed) external cages. It will again depend on process connection, process condition, customer specification, … how the exte nal cage will be designed. Below are some typical examples. Many other designs are possible, consult the factory for more details.

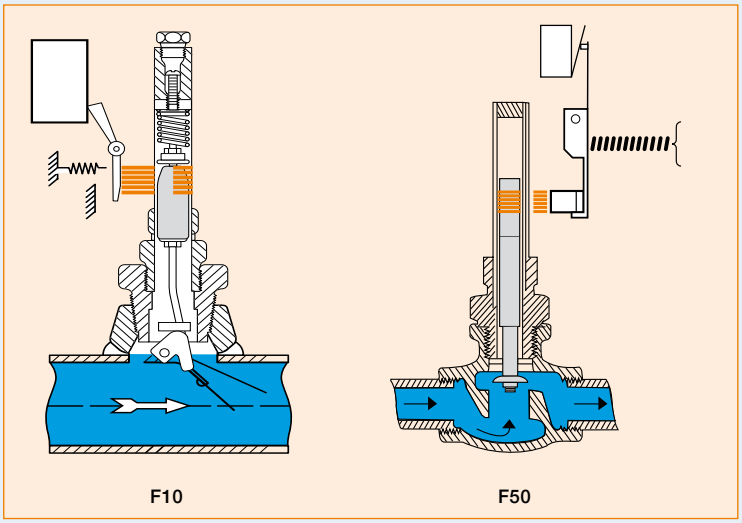
MECHANICAL FLOW

F10

The actuating vane is magnetically linked to a pivoted electric (or pneumatic) switch, which is isolated from the process by a non-magnetic barrier tube. As the actuating vane moves with an increase in flo , it drives a magnetic sleeve into the field of a permanent magnet located ou - side the barrier tube which trips the switch. As flow d - creases, the actuating vane returns to a vertical position, allowing the magnet and switch assembly to return to the “No Flow” position.

F50

The rate of flow th ough the valve body raises or lowers the disc. This in turn raises or lowers the magnetic sleeve, within its sealed non-magnetic barrier tube. On an increas- ing flow rate, the magnetic sleeve rises into the field of th permanent magnet, located outside the barrier tube, actu- ating the attached switch mechanism. When the flow rate drops, below the rate for which the flow disc is calibrated, a reversal of this action occurs.



F10 - F50
Flow switch

DESCRIPTION

Flow switches are highly reliable devices sensing the start or stop of flow in horizontal pipelines containing oil and petroleum derivatives, chemicals, water, or air.

Vane actuated model F10 switches are used on gas or liquid flow applications in 2" or larger pipe sizes.

Disc actuated model F50 switches are in-line type sensing clean liquids in 2" or smaller pipe sizes.

FEATURES

Actuation on increasing or decreasing flow.

Special sensing elements for non-standard or high flow applications.

Designed for horizontal pipe applications.

Standard anti-corrosive protection.

Model F10:
- field adjustable
- low pressure drop
- process temperature up to +230 °C (+450 °F)
- process pressure up to 69 bar (1000 psi)
- standard flow vanes for 2" thru 10" flow lines.

Model F50:
- no calibration required
- bronze or stainless steel construction
- process temperature up to +400 °C (+750 °F)
- process pressure up to 79,3 bar (1150 psi)
- bodies for flow lines from 3/4" to 2".

APPLICATIONS

Pump staging or failure.

Pipeline flow detection.

Valve failure.

Loss of pipeline flow.

Pipe blockage/rupture.

Pump inlet flow protection.

Check valve blockage/leakage.

Alarm on eyewash or shower safety station.

AGENCY APPROVALS

	Ex d	Ex ia	Ex n	Ex t	XP	IS	NI	Other
ATEX	•	•						
CCOE	•							
CSA					•			
FM					•			
EAC (GOST)	•	•						
IEC	•							
Inmetro	•							
Korea	•							
NEPSI		•						CPA

Other approvals are available, consult factory for more details

Appendix – Technical Guide

This Technical Guide is the result of a combined effort by the Engineering, Sales, and Marketing Departments.

All reasonable efforts have been made to accurately compile the information contained in this guide. However, no warranty is made with regard to any such information, and Magnetrol cannot assume responsibility for any possible errors or any direct or indirect result of the use of such information.

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Conversions: Metric Values

The table below provides a fast and easy means of conversion from one metric notation to another. The value labeled "Unit" represents a basic unit of measurement, such as meter, gram, ohm, erg, etc. First, locate the original value in the left-hand column. Follow the row horizontally to the vertical column headed by the prefix of the desired value. The arrow and figure at this intersection represent the direction in which the decimal point should be moved and the number of places to move it.

Example: Convert 0.15 kilowatts to watts. Starting at the "Kilo-" box in the left-hand column, move horizontally to the column headed by "Unit" (since watt is a basic unit of measurement), and read 3→ . Thus 0.15 kilowatts is the equivalent of 150 watts.

Example: Convert 4,500 kilohertz to megahertz, read in the box horizontal to "Kilo-" and under "Mega-" the notation ← 3, which means a shift of the decimal point three places to the left. Thus, 4,500 kilohertz is the equivalent of 4.5 megahertz.

Original Value	Desired Value													
	Tera-	Giga-	Mega-	Myria-	Kilo-	Hecto-	Deka-	Unit	Deci-	Centi-	Milli-	Micro-	Nano-	Pico-
Tera-		3 →	6 →	8 →	9 →	10 →	11 →	12 →	13 →	14 →	15 →	18 →	21 →	24 →
Giga-	← 3		3 →	5 →	6 →	7 →	8 →	9 →	10 →	11 →	12 →	15 →	18 →	21 →
Mega-	← 6	← 3		2 →	3 →	4 →	5 →	6 →	7 →	8 →	9 →	12 →	15 →	18 →
Myria-	← 8	← 5	← 2		1 →	2 →	3 →	4 →	5 →	6 →	7 →	10 →	13 →	16 →
Kilo-	← 9	← 6	← 3	← 1		1 →	2 →	3 →	4 →	5 →	6 →	9 →	12 →	15 →
Hecto-	← 10	← 7	← 4	← 2	← 1		1 →	2 →	3 →	4 →	5 →	8 →	11 →	14 →
Deka-	← 11	← 8	← 5	← 3	← 2	← 1		1 →	2 →	3 →	4 →	7 →	10 →	13 →
Unit	← 12	← 9	← 6	← 4	← 3	← 2	← 1		1 →	2 →	3 →	6 →	9 →	12 →
Deci-	← 13	← 10	← 7	← 5	← 4	← 3	← 2	← 1		1 →	2 →	5 →	8 →	11 →
Centi-	← 14	← 11	← 8	← 6	← 5	← 4	← 3	← 2	← 1		1 →	4 →	7 →	10 →
Milli-	← 15	← 12	← 9	← 7	← 6	← 5	← 4	← 3	← 2	← 1		3 →	6 →	9 →
Micro-	← 18	← 15	← 12	← 10	← 9	← 8	← 7	← 6	← 5	← 4	← 3		3 →	6 →
Nano-	← 21	← 18	← 15	← 13	← 12	← 11	← 10	← 9	← 8	← 7	← 6	← 3		3 →
Pico-	← 24	← 21	← 18	← 16	← 15	← 14	← 13	← 12	← 11	← 10	← 9	← 6	← 3	

Conversions: Metric Prefixes

atto	a	one-quintillionth	0.000 000 000 000 000 001	10^{-18}
femto	f	one-quadrillionth	0.000 000 000 000 001	10^{-15}
pico	p	one-trillionth	0.000 000 000 001	10^{-12}
nano	n	one-billionth	0.000 000 001	10^{-9}
micro	μ	one-millionth	0.000 001	10^{-6}
milli	m	one-thousandth	0.001	10^{-3}
centi	c	one-hundredth	0.01	10^{-2}
deci	d	one-tenth	0.1	10^{-1}
uni		one	1.0	10^{0}
deka	da	ten	10.0	10^{1}
hecto	h	one hundred	100.0	10^{2}
kilo	k	one thousand	1 000.0	10^{3}
mega	M	one million	1 000 000.0	10^{6}
giga	G	one billion	1 000 000 000.0	10^{9}
tera	T	one trillion	1 000 000 000 000.0	10^{12}

Conversions: Temperature

Locate temperature in middle column. If in degrees Celsius, read Fahrenheit equivalent in right hand column; if in degrees Fahrenheit, read Celsius equivalent in left hand column.

–459.4° to 0°			1 to 60°			61° to 290°			300° to 890°			900° to 3000°		
C	C / F	F	C	C / F	F	C	C / F	F	C	C / F	F	C	C / F	F
–273.1	–459.7		–17.2	1	33.8	16.1	61	141.8	149	300	572	482	900	1652
–268	–450		–16.7	2	35.6	16.7	62	143.6	154	310	590	488	910	1670
–262	–440		–16.1	3	37.4	17.2	63	145.4	160	320	608	493	920	1688
–257	–430		–15.6	4	39.2	17.8	64	147.2	166	330	626	499	930	1706
–251	–420		–15.0	5	41.0	18.3	65	149.0	171	340	644	504	940	1724
–246	–410		–14.4	6	42.8	18.9	66	150.8	177	350	662	510	950	1742
–240	–400		–13.9	7	44.6	19.4	67	152.6	182	360	680	516	960	1760
–234	–390		–13.3	8	46.4	20.0	68	154.4	188	370	698	521	970	1778
–229	–380		–12.8	9	48.2	20.6	69	156.2	193	380	716	527	980	1796
–223	–370		–12.2	10	50.0	21.1	70	158.0	199	390	734	532	990	1814
–218	–360		–11.7	11	51.8	21.7	71	159.8	204	400	752	538	1000	1832
–212	–350		–11.1	12	53.6	22.2	72	161.6	210	410	770	549	1020	1868
–207	–340		–10.6	13	55.4	22.8	73	163.4	216	420	788	560	1040	1904
–201	–330		–10.0	14	57.2	23.3	74	165.2	221	430	806	571	1060	1940
–196	–320		– 9.4	15	59.0	23.9	75	167.0	227	440	824	582	1080	1976
–190	–310		– 8.9	16	60.8	24.4	76	168.8	232	450	842	593	1100	2012
–184	–300		– 8.3	17	62.6	25.0	77	170.6	238	460	860	604	1120	2048
–179	–290		– 7.8	18	64.4	25.6	78	172.4	243	470	878	616	1140	2084
–173	–280		– 7.2	19	66.2	26.1	79	174.2	249	480	896	627	1160	2120
–169	–273.1	–459.7	– 6.7	20	68.0	26.7	80	176.0	254	490	914	638	1180	2156
–168	–270	–454	– 6.1	21	69.8	27.2	81	177.8	260	500	932	649	1200	2192
–162	–260	–436	– 5.6	22	71.6	27.8	82	179.6	266	510	940	660	1220	2228
–157	–250	–418	– 5.0	23	73.4	28.3	83	181.4	271	520	968	671	1240	2264
–151	–240	–400	– 4.4	24	75.2	28.9	84	183.2	277	530	986	682	1260	2300
–146	–230	–382	– 3.9	25	77.0	29.4	85	185.0	282	540	1004	693	1280	2336
–140	–220	–364	– 3.3	26	78.8	30.0	86	186.8	288	550	1022	704	1300	2372
–134	–210	–346	– 2.8	27	80.6	30.6	87	188.6	293	560	1040	732	1350	2462
–129	–200	–328	– 2.2	28	82.4	31.1	88	190.4	299	570	1058	760	1400	2552
–123	–190	–310	– 1.7	29	84.2	31.7	89	192.2	304	580	1076	788	1450	2642
–118	–180	–292	– 1.1	30	86.0	32.2	90	194.0	310	590	1094	816	1500	2732
–112	–170	–274	– 0.6	31	87.8	32.8	91	195.8	316	600	1112	843	1550	2822
–107	–160	–256	0.0	32	89.6	33.3	92	197.6	321	610	1130	871	1600	2912
–101	–150	–238	0.6	33	91.4	33.9	93	199.4	327	620	1148	899	1650	3002
– 96	–140	–220	1.1	34	93.2	34.4	94	201.2	332	630	1166	927	1700	3092
– 90	–130	–202	1.7	35	95.0	35.0	95	203.0	338	640	1184	954	1750	3182
– 84	–120	–184	2.2	36	96.8	35.6	96	204.8	343	650	1202	982	1800	3272
– 79	–110	–166	2.8	37	98.6	36.1	97	206.6	349	660	1220	1010	1850	3362
– 73	–100	–148	3.3	38	100.4	36.7	98	208.4	354	670	1238	1038	1900	3452
– 68	– 90	–130	3.9	39	102.2	37.2	99	210.2	360	680	1256	1066	1950	3542
– 62	– 80	–112	4.4	40	104.0	37.8	100	212.0	366	690	1274	1093	2000	3632
– 57	– 70	– 94	5.0	41	105.8	43	110	230	371	700	1292	1121	2050	3722
– 51	– 60	– 76	5.6	42	107.6	49	120	248	377	710	1310	1149	2100	3812
– 46	– 50	– 58	6.1	43	109.4	54	130	266	382	720	1328	1177	2150	3902
– 40	– 40	– 40	6.7	44	111.2	60	140	284	388	730	1346	1204	2200	3992
– 34	– 30	– 22	7.2	45	113.0	66	150	302	393	740	1364	1232	2250	4082
– 29	– 20	– 4	7.8	46	114.8	71	160	320	399	750	1382	1260	2300	4172
– 23	– 10	14	8.3	47	116.6	77	170	338	404	760	1400	1288	2350	4262
– 17.8	0	32	8.9	48	118.4	82	180	356	410	770	1418	1316	2400	4352
			9.4	49	120.2	88	190	374	416	780	1436	1343	2450	4442
			10.0	50	122.0	92	200	392	421	790	1454	1371	2500	4532
			10.6	51	123.8	99	210	410	427	800	1472	1399	2550	4622
			11.1	62	125.6	100	212	413.6	432	810	1490	1427	2600	4712
			11.7	53	127.4	104	220	428	438	820	1508	1454	2650	4802
			12.2	54	129.2	110	230	446	443	830	1526	1482	2700	4892
			12.8	55	131.0	116	240	464	449	840	1544	1510	2750	4982
			13.3	56	132.8	121	250	482	454	850	1562	1538	2800	5072
			13.9	57	134.6	127	260	500	460	860	1580	1566	2850	5162
			14.4	58	136.4	132	270	518	466	870	1598	1593	2900	5252
			15.0	59	138.2	138	280	536	471	880	1616	1621	2950	5342
			15.6	60	140.0	143	290	554	477	890	1634	1649	3000	5432

Conversions: Flow Rate

Velocity in Feet per Second.
Find the volume flow rate (gallons per minute) in the left hand column, read the velocity flow rate (feet per second) for a specific line size in the right hand column. (Based on Schedule 40 pipe.)

GPM	Line Size 1”	Line Size 1 1/4”	Line Size 1 1/2”	Line Size 2”	Line Size 2 1/2”	Line Size 3”	Line Size 4”	Line Size 5”	Line Size 6”	Line Size 8”	Line Size 10”
0.03	0.011										
0.05	0.019	0.011	0.008								
0.10	0.037	0.021	0.016	0.010	0.007						
0.25	0.093	0.054	0.039	0.024	0.017	0.011					
0.50	0.186	0.107	0.079	0.048	0.034	0.022	0.013				
0.75	0.279	0.161	0.118	0.072	.0050	0.033	0.019	0.012			
1	0.371	0.214	0.158	0.095	0.067	0.043	0.025	0.016	0.011		
2	0.743	0.428	0.315	0.191	0.134	0.087	0.050	0.032	0.022	0.013	
3	1.114	0.643	0.473	0.286	0.201	0.130	0.076	0.048	0.033	0.019	0.012
4	1.485	0.857	0.630	0.382	0.268	0.174	0.101	0.064	0.044	0.026	0.016
5	1.857	1.071	0.788	0.477	0.335	0.217	0.126	0.080	0.056	0.032	0.020
6	2.228	1.285	0.945	0.573	0.402	0.261	0.151	0.096	0.067	0.038	0.024
8	2.971	1.714	1.261	0.764	0.537	0.347	0.202	0.128	0.089	0.051	0.033
10	3.713	2.142	1.576	0.955	0.671	0.434	0.252	0.160	0.111	0.064	0.041
15	5.570	3.213	2.364	1.432	1.006	0.651	0.378	0.240	0.167	0.096	0.061
20	7.427	4.285	3.151	1.910	1.341	0.869	0.504	0.321	0.222	0.128	0.081
25	9.283	5.356	3.939	2.387	1.677	1.086	0.630	0.401	0.278	0.160	0.102
30		6.427	4.727	2.865	2.012	1.303	0.756	0.481	0.333	0.192	.0122
35		7.498	5.515	3.342	2.347	1.520	0.882	0.561	0.389	0.224	0.142
40		8.569	6.303	3.820	2.683	1.737	1.008	0.641	0.444	0.257	0.163
45		9.640	7.091	4.297	3.018	1.954	1.134	0.721	0.500	0.289	0.183
50		10.712	7.878	4.775	3.353	2.172	1.260	0.801	0.555	0.321	0.203
60			9.454	5.730	4.024	2.606	1.512	0.962	0.666	0.385	0.244
70			11.030	6.685	4.695	3.040	1.764	1.122	0.777	0.449	0.285
80				7.640	5.365	3.474	2.016	1.282	0.889	0.513	0.326
100				9.550	6.707	4.343	2.520	1.603	1.111	0.641	0.407
125					8.384	5.429	3.150	2.004	1.388	0.802	0.509
150					10.060	6.515	3.781	2.404	1.666	0.962	0.610
175					11.737	7.600	4.411	2.805	1.944	1.122	0.712
200						8.686	5.041	3.206	2.221	1.283	0.814
225						9.772	5.671	3.606	2.499	1.443	0.916
250						10.858	6.301	4.007	2.777	1.603	1.017
275						11.944	6.931	4.408	3.054	1.764	1.119
300							7.561	4.809	3.332	1.924	1.221
325							8.191	5.209	3.610	2.084	1.323
350							8.821	5.610	3.887	2.245	1.424
375							9.451	6.011	4.165	2.405	1.526
400							10.081	6.412	4.443	2.565	1.628
425							10.712	6.812	4.720	2.726	1.730
450								7.213	4.998	2.886	1.831
475								7.614	5.276	3.046	1.933
500								8.014	5.553	3.207	2.035
550								8.816	6.109	3.527	2.238
600								9.617	6.664	3.848	2.442
650								10.419	7.219	4.169	2.645
700									7.775	4.489	2.849
750									8.330	4.810	3.052
800									8.885	5.131	3.256
850									9.441	5.451	3.459
900									9.996	5.772	3.662
950									10.551	6.093	3.866
1,000										6.413	4.069
1,100										7.055	4.476
1,200										7.696	4.883
1,300										8.337	5.290
1,400										8.979	5.697
1,500										9.620	6.104
1,600										10.261	6.511
1,800											7.325
2,000											8.139
2,500											10.174

Conversions: Flow Rate (cont.)

Velocity in Meters per Second

Find the volume flow rate (cubic meters per hour) in the left hand column, read the velocity flow rate (meters per second) for a specific line size in the right hand column. (Based on Schedule 40 pipe.)

m^3/hr	Line Size 1”	Line Size 1 1/4”	Line Size 1 1/2”	Line Size 2”	Line Size 2 1/2”	Line Size 3”	Line Size 4”	Line Size 5”	Line Size 6”	Line Size 8”	Line Size 10”
0.02	0.010										
0.05	0.025	0.014	0.011								
0.10	0.050	0.029	0.021	0.013	0.009						
0.15	0.075	0.043	0.032	0.019	0.014	0.009					
0.20	0.100	0.057	0.042	0.026	0.018	0.012	0.007				
0.25	0.125	0.072	0.053	0.032	0.023	0.015	0.008	0.005			
0.30	0.149	0.086	0.063	0.038	0.027	0.017	0.010	0.006	0.004		
0.35	0.174	0.101	0.074	0.045	0.032	0.020	0.012	0.008	0.005	0.003	
0.40	0.199	0.115	0.085	0.051	0.036	0.023	0.014	0.009	0.006	0.003	0.002
0.50	0.249	0.144	0.106	0.064	0.045	0.029	0.017	0.011	0.007	0.004	0.003
0.75	0.374	0.216	0.159	0.096	0.068	0.044	0.025	0.016	0.011	0.006	0.004
1.0	0.498	0.287	0.211	0.128	0.090	0.058	0.034	0.022	0.015	0.009	0.005
1.5	0.747	0.431	0.317	0.192	0.135	0.087	0.051	0.032	0.022	0.013	0.008
2.0	0.997	0.575	0.423	0.256	0.180	0.117	0.068	0.043	0.030	0.017	0.011
2.5	1.246	0.719	0.529	0.320	0.225	0.146	0.085	0.054	0.037	0.022	0.014
3.0	1.495	0.862	0.634	0.384	0.270	0.175	0.101	0.065	0.045	0.026	0.016
3.5	1.744	1.006	0.740	0.449	0.315	0.204	0.118	0.075	0.052	0.030	0.019
4.0	1.993	1.150	0.846	0.513	0.360	0.233	0.135	0.086	0.060	0.034	0.022
4.5	2.242	1.294	0.952	0.577	0.405	0.262	0.152	0.097	0.067	0.039	0.025
5.0	2.492	1.437	1.057	0.641	0.450	0.291	0.169	0.108	0.075	0.043	0.027
5.5	2.741	1.581	1.163	0.705	0.495	0.321	0.186	0.118	0.082	0.047	0.030
6.0		1.725	1.269	0.769	0.540	0.350	0.203	0.129	0.089	0.052	0.033
7.0		2.012	1.480	0.897	0.630	0.048	0.237	0.151	0.104	0.060	0.038
8.0		2.300	1.692	1.025	0.720	0.466	0.271	0.172	0.119	0.069	0.044
10		2.875	2.114	1.282	0.900	0.583	0.338	0.215	0.149	0.086	0.055
12			2.537	1.538	1.080	0.699	0.406	0.258	0.179	0.103	0.066
14				1.794	1.250	0.815	0.474	0.301	0.209	0.120	0.076
16				2.050	1.440	0.933	0.541	0.344	0.238	0.138	0.087
18				2.307	1.620	1.049	0.609	0.387	0.268	0.155	0.098
20				2.563	1.800	1.166	0.676	0.430	0.298	0.172	0.109
22				2.819	1.980	1.282	0.744	0.473	0.328	0.189	0.120
24					2.160	1.399	0.812	0.516	0.358	0.207	0.131
26					2.340	1.515	0.879	0.559	0.388	0.224	0.142
28					2.520	1.632	0.947	0.602	0.417	0.241	0.153
30					2.700	1.748	1.015	0.645	0.447	0.258	0.164
32					2.880	1.865	1.082	0.688	0.477	0.275	0.175
34					3.060	1.982	1.150	0.731	0.507	0.293	0.186
36						2.098	1.218	0.774	0.537	0.310	0.197
38						2.215	1.285	0.817	0.566	0.327	0.208
40						2.331	1.353	0.860	0.596	0.344	0.218
45						2.623	1.522	0.968	0.671	0.387	0.246
50						2.914	1.691	1.075	0.745	0.430	0.273
55						3.205	1.860	1.183	0.820	0.473	0.300
60							2.029	1.291	0.894	0.516	0.328
65							2.198	1.398	0.969	0.559	0.355
70							2.368	1.506	1.043	0.602	0.382
75							2.537	1.613	1.118	0.645	0.410
80							2.706	1.721	1.192	0.689	0.437
90							3.044	1.936	1.341	0.775	0.491
100								2.151	1.490	0.861	0.546
120								2.581	1.789	1.033	0.655
140								3.011	2.087	1.205	0.765
160									2.385	1.377	0.874
180									2.683	1.549	0.983
200										1.721	1.092
250										2.152	1.365
300										2.582	1.638
350										3.012	1.911
400											2.184
450											2.457
500											2.730

Conversions: Miscellaneous

TO CONVERT	INTO	MULTIPLY BY
	A	
acres	sq. feet	43,560.0
"	sq. meters	4,047.0
"	sq. miles	1.562×10^{-3}
"	sq. yards	4,840.0
acre-feet	cu. feet	43,560.0
"	gallons	3.259×10^{5}
amperes/sq. cm.	amps./sq. in.	6.452
"	amps/sq. meter	10^{4}
amperes/sq. in.	amps/sq. cm.	0.1550
"	amps/sq. meter	1,550.0
amperes/sq. meter	amps/sq. cm.	10^{-4}
"	amps/sq. in.	6.452×10^{-4}
ampere-hours	coulombs	3,600.0
"	faradays	0.03731
ampere-turns	gilberts	1.257
ampere-turns/cm.	amp-turns/in.	2.540
"	amp-turns/meter	100.0
"	gilberts/cm.	1.257
ampere-turns/in.	amp-turns/cm.	0.3937
"	amp-turns/meter	39.37
"	gilberts/cm.	0.4950
ampere-turns/meter	amp-turns/cm.	0.01
"	amp-turns/in.	0.0254
"	gilberts/cm.	0.01257
ares	acres	0.02471
"	sq. meters	100.0
atmospheres	cms. of mercury	76.0
"	ft. of water (at 4°C)	33.90
"	in. of mercury (at 0°C)	29.92
"	kgs./sq. cm.	1.0333
"	kgs./sq. meter	10,332.0
"	pounds/sq. in.	14.70
"	tons/sq. ft.	1.058
	B	
barrels (oil)	gallons (oil)	42.0
bars	atmospheres	0.9869
"	dynes/sq. cm.	1
"	kgs./sq. meter	1.020×10^{4}
"	pounds/sq. ft.	2,089.0
"	pounds/sq. in.	14.50
Btu	ergs	1.0550×10^{10}
"	foot-lbs.	778.3
"	gram-calories	252.0
"	horsepower-hrs.	3.931×10^{-4}
"	joules	1,054.8
"	kilogram-calories	0.2520
"	kilogram-meters	107.5
"	kilowatt-hrs.	2.928×10^{-4}
Btu/hr.	foot-pounds/sec.	0.2162
"	gram-cal./sec.	0.0700
"	horsepower-hrs.	3.929×10^{-4}
"	watts	0.2931
Btu/min.	foot-lbs./sec.	12.96
"	horsepower	0.02356
"	kilowatts	0.01757
"	watts	17.57
Btu/sq. ft./min.	watts/sq. in.	0.1221
bushels	cu. ft.	1.2445
"	cu. in.	2,150.4
"	cu. meters	0.03524
"	liters	35.24
"	pecks	4.0
"	pints (dry)	64.0
"	quarts (dry)	32.0

TO CONVERT	INTO	MULTIPLY BY
	C	
centares (centiares)	sq. meters	1.0
Centigrade	Fahrenheit	(C° x 9/5) + 32
centigrams	grams	0.01
centiliters	liters	0.01
centimeters	feet	3.281×10^{-2}
"	inches	0.3937
"	kilometers	10^{-5}
"	meters	0.01
"	miles	6.214×10^{-6}
"	millimeters	10.0
"	mils	393.7
"	yards	1.094×10^{-2}
centimeter-dynes	cm.-grams	1.020×10^{-3}
"	meter-kgs.	1.020×10^{-8}
"	pound-feet	7.376×10^{-8}
centimeter-grams	cm.-dynes	980.7
"	meter-kgs.	10^{-5}
"	pound-feet	7.233×10^{-5}
centimeters of mercury	atmospheres	0.01310
"	feet of water	0.4401
"	kgs./sq. meter	136.0
"	pounds/sq. ft.	27.85
"	pounds/sq. in.	0.1934
centimeters/sec.	feet/min.	1.1969
"	feet/sec.	0.03281
"	kilometers/hr.	0.036
"	knots	0.1943
"	meters/min.	0.6
"	miles/hr.	0.02237
"	miles/min.	3.728×10^{-4}
centimeters/sec./sec.	feet/sec./sec.	0.03281
"	kms./hr./sec.	0.036
"	meters/sec./sec.	0.01
"	miles/hr./sec.	0.02237
circular mils	sq. cms.	5.067×10^{-6}
"	sq. mils	0.7854
"	sq. inches	7.854×10^{-7}
coulombs	faradays	1.036×10^{-5}
coulombs/sq. cm.	coulombs/sq. in.	64.52
"	coulombs/sq. meter	10^{4}
coulombs/sq. in.	coulombs/sq. cm.	0.1550
"	coulombs/sq. meter	1,550.0
coulombs/sq. meter	coulombs/sq. cm.	10^{-4}
"	coulombs/sq. in.	6.452×10^{-4}
cubic centimeters	cu. feet	3.531×10^{-5}
"	cu. inches	0.06102
"	cu. meters	10^{-6}
"	cu. yards	1.308×10^{-6}
"	gallons (U.S. liq.)	2.642×10^{-4}
"	liters	0.001
"	pints (U.S. liq.)	2.113×10^{-3}
"	quarts (U.S. liq.)	1.057×10^{-3}
cubic feet	bushels (dry)	0.8036
"	cu. cms.	28,320.0
"	cu. inches	1,728.0
"	cu. meters	0.02832
"	cu. yards	0.03704
"	gallons (U.S. liq.)	7.48052
"	liters	28.32
"	pints (U.S. liq.)	59.84
"	quarts (U.S. liq.)	29.92
cubic feet/min.	cu. cms./sec.	472.0
"	gallons/sec.	0.1247
"	liters/sec.	0.4720
"	pounds of water/min.	62.43

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
C (cont.)		
cubic feet/sec.	million gals./day	0.646317
"	gallons/min.	448.831
cubic inches	cu. cms.	16.39
"	cu. feet	5.787×10^{-4}
"	cu. meters	1.639×10^{-5}
"	cu. yards	2.143×10^{-5}
"	gallons (U.S. liq.)	4.329×10^{-3}
"	liters	0.01639
"	mil.-ft.	1.061×10^{5}
"	pints (U.S. liq.)	0.03463
"	quarts (U.S. liq.)	0.01732
cubic meters	bushels (dry)	28.38
"	cu. cms.	10^{6}
"	cu. feet	35.31
"	cu. inches	61,023.0
"	cu. yards	1.308
"	gallons (U.S. liq.)	264.2
"	liters	10^{3}
"	pints (U.S. liq.)	2,113.0
"	quarts (U.S. liq.)	1,057.0
cubic yards	cu. cms.	7.646×10^{5}
"	cu. feet	27.0
"	cu. inches	46,656.0
"	cu. meters	0.7646
"	gallons (U.S. liq.)	202.0
"	liters	764.6
"	pints (U.S. liq.)	1,615.9
"	quarts (U.S. liq.)	807.9
cubic yards/min.	cubic ft./sec.	0.45
"	gallons/sec.	3.367
"	liters/sec.	12.74
D		
days	hours	24.0
"	minutes	1,440.0
"	seconds	86,400.0
decigrams	grams	0.1
deciliters	liters	0.1
decimeters	meters	0.1
degrees (angle)	minutes	60.0
"	quadrants	0.01111
"	radians	0.01745
"	seconds	3,600.0
degrees/sec.	radians/sec.	0.01745
"	revolutions/min.	0.1667
"	revolutions/sec.	2.778×10^{-3}
dekagrams	grams	10.0
dekaliters	liters	10.0
dekameters	meters	10.0
drams	grams	1.7718
"	grains	27.3437
"	ounces	0.0625
dynes	grams	1.020×10^{-3}
"	joules/cm.	10^{7}
"	joules/meter (newtons)	10^{-5}
"	kilograms	1.020×10^{-6}
"	poundals	7.233×10^{-5}
"	pounds	2.248×10^{-6}
dynes/sq. cm.	bars	1
dynes/sq. meters	bars	10^{-4}
E		
ergs	Btu	9.480×10^{-11}
"	dyne-centimeters	1.0
"	foot-pounds	7.378×10^{-8}
"	gram-calories	2.389×10^{-8}

TO CONVERT	INTO	MULTIPLY BY
E (cont.)		
ergs (continued)	gram-cms.	1.020×10^{-3}
"	horsepower-hrs.	3.7250×10^{-14}
"	joules	10^{-7}
"	kg.-calories	2.389×10^{-11}
"	kg.-meters	1.020×10^{-8}
"	kilowatt-hrs.	0.2778×10^{-13}
"	watt-hours	0.2778×10^{-10}
ergs/sec.	Btu/min.	$5,688.0 \times 10^{-9}$
"	ft.-lbs./min.	4.427×10^{-6}
"	ft.-lbs./sec.	7.3756×10^{-8}
"	horsepower	1.341×10^{-10}
"	kg.-calories/min.	1.433×10^{-9}
"	kilowatts	10^{-10}
F		
farads	microfarads	10^{6}
faradays	ampere-hours	26.80
"	coulombs	9.649×10^{4}
fathoms	feet	6.0
feet	centimeters	30.48
"	kilometers	3.048×10^{-4}
"	meters	0.3048
"	miles (naut.)	1.645×10^{-4}
"	miles (stat.)	1.894×10^{-4}
"	millimeters	304.8
"	mils	1.2×10^{4}
feet of water	atmospheres	0.02950
"	in. of mercury	0.8826
"	kgs./sq. cm.	0.03048
"	kgs./sq. meter	304.8
"	pounds/sq. ft.	62.43
"	pounds/sq. in.	0.4335
feet/min.	cms./sec.	0.5080
"	feet/sec.	0.01667
"	kms./hr.	0.01829
"	meters/min.	0.3048
"	miles/hr.	0.01136
feet/sec.	cms./sec.	30.48
"	kms./hr.	1.097
"	knots	0.5921
"	meters/min.	18.29
"	miles/hr.	0.6818
"	miles/min.	0.01136
feet/sec./sec.	cms./sec./sec.	30.48
"	kms./hr./sec.	1.097
"	meters/sec./sec.	0.3048
"	miles/hr./sec.	0.6818
feet/100 feet	per cent grade	1.0
foot-pounds	Btu	1.286×10^{-3}
"	ergs	1.356×10^{7}
"	grams-calories	0.3238
"	hp-hrs.	5.050×10^{-7}
"	joules	1.356
"	kg.-calories	3.24×10^{-4}
"	kg.-meters	0.1383
"	kilowatt-hrs.	3.766×10^{-7}
foot-pounds/min.	Btu/min.	1.286×10^{-3}
"	foot-pounds/sec.	0.01667
"	horsepower	3.030×10^{-5}
"	kg.-calories/min.	3.24×10^{-4}
"	kilowatts	2.260×10^{-5}
foot-pounds/sec.	Btu/hr.	4.6263
"	Btu/min.	0.07717
"	horsepower	1.818×10^{-3}
"	kg.-calories/min.	0.01945
"	kilowatts	1.356×10^{-3}
furlongs	rods	40.0
"	feet	660.0

Conversions: Miscellaneous (cont.)

G

TO CONVERT	INTO	MULTIPLY BY
gallons	cu. cms.	3,785.0
"	cu. feet	0.1337
"	cu. inches	231.0
"	cu. meters	3.785×10^{-3}
"	cu. yards	4.951×10^{-3}
"	liters	3.785
"	pints	8.0
"	quarts	4.0
gallons (liq. Br. Imp.)	gallons (U.S. liq.)	1.20095
gallons (U.S.)	gallons (Imp.)	0.83267
gallons of water	pounds of water	8.3453
gallons/min.	cu. ft./sec.	2.228×10^{-3}
"	liters/sec.	0.06308
"	cu. ft./hr.	8.0208
gausses	lines/sq. in.	6.452
"	webers/sq. cm.	10^{-8}
"	webers/sq. in.	6.452×10^{-8}
"	webers/sq. meter	10^{-4}
gilberts	ampere-turns	0.7958
gilberts/cm.	amp-turns/cm.	0.7958
"	amp-turns/in.	2.021
"	amp-turns/meter	79.58
gils	liters	0.1183
"	pints (liq.)	0.25
grains (troy)	grains (avdp.)	1.0
"	grams	0.06480
"	ounces (avdp.)	2.0833×10^{-3}
"	pennyweight (troy)	0.04167
grains/U.S. gal.	parts/million	17.118
"	pounds/million gal.	142.86
grains/Imp. gal.	parts/million	14.286
grams	dynes	980.7
"	grains	15.43
"	joules/cm	9.807×10^{-5}
"	joules/meter (newtons)	9.807×10^{-3}
"	kilograms	10^{-3}
"	milligrams	10^{3}
"	ounces (avdp.)	0.03527
"	ounces (troy)	0.03215
"	poundals	0.07093
"	pounds	2.205×10^{-3}
grams/cm.	pounds/inch	5.600×10^{-3}
grams/cu. cm.	pounds/cu. ft.	62.43
"	pounds/cu. in.	0.03613
"	pounds/mil.-foot	3.405×10^{-7}
grams/liter	grains/gal.	58.417
"	pounds/1,000 gal.	8.345
"	pounds/cu. ft.	0.062427
"	parts/million	1,000.0
grams/sq. cm.	pounds/sq. ft.	2.0481
gram-calories	Btu	3.9683×10^{-3}
"	ergs	4.1868×10^{7}
"	foot-pounds	3.0880
"	horsepower-hrs.	1.5596×10^{-6}
"	kilowatt-hrs.	1.1630×10^{-6}
"	watt-hrs.	1.1630×10^{-3}
gram-calories/sec.	Btu/hr.	14.286
gram-centimeters	Btu	9.297×10^{-8}
"	ergs	980.7
"	joules	9.807×10^{-5}
"	kg.-cal.	2.343×10^{-8}
"	kg-meters	10^{-5}

H

TO CONVERT	INTO	MULTIPLY BY
hectares	acres	2.471
"	sq. foot	1.076×10^{5}
hectograms	grams	100.0
hectoliters	liters	100.0
hectometers	meters	100.0
hectowatts	watts	100.0
henries	millihenries	10^{3}
horsepower	Btu/min.	42.44
"	foot-lbs./min.	33,000.0
"	foot-lbs./sec.	550.0
horsepower (metric) (542.5 ft. lb./sec.)	horsepower (550 ft. lb./sec.)	0.9863
horsepower (550 ft. lb./sec.)	horsepower (metric) (542.5 ft. lb./sec.)	1.014
horsepower	kg.-calories/min.	10.68
"	kilowatts	0.7457
"	watts	745.7
horsepower (boiler)	Btu/hr.	33.479
"	kilowatts	9.803
horsepower-hrs.	Btu	2,547.0
"	ergs	2.6845×10^{13}
"	foot-lbs.	1.98×10^{6}
"	gram-calories	641,190.0
"	joules	2.694×10^{6}
"	kg.-calories	641.1
"	kg.-meters	2.737×10^{5}
"	kilowatt-hrs.	0.7457
hours	days	4.167×10^{-2}
"	minutes	60.0
"	seconds	3,600.0
"	weeks	5.952×10^{-3}

I

TO CONVERT	INTO	MULTIPLY BY
inches	centimeters	2.540
"	feet	8.333×10^{-2}
"	meters	2.540×10^{-2}
"	miles	1.578×10^{-5}
"	millimeters	25.40
"	mils	10^{3}
"	yards	2.778×10^{-2}
inches of mercury	atmospheres	0.03342
"	feet of water	1.133
"	kgs./sq. cm.	0.03453
"	kgs./sq. meter	345.3
"	pounds/sq. ft.	70.73
"	pounds/sq. in.	0.4912
inches of water (at 4°C)	atmospheres	2.458×10^{-3}
"	inches of mercury	0.07355
"	kgs./sq. cm.	2.540×10^{-3}
"	ounces/sq. in.	0.5781
"	pounds/sq. ft.	5.204
"	pounds/sq. in.	0.03613

J

TO CONVERT	INTO	MULTIPLY BY
joules	Btu	9.480×10^{-4}
"	ergs	10^{7}
"	foot-pounds	0.7376
"	kg.-calories	2.389×10^{-4}
"	kg.-meters	0.1020
"	watt-hrs.	2.778×10^{-4}
joules/cm.	grams	1.020×10^{-4}
"	dynes	10^{7}
"	joules/meter (newtons)	100.0
"	poundals	723.3
"	pounds	22.48

Conversions: Miscellaneous (cont.)

K

TO CONVERT	INTO	MULTIPLY BY
kilograms	dynes	980,665.0
"	grams	10^3
"	joules/cm.	0.09807
"	joules/meter (newtons)	9.807
"	poundals	70.93
"	pounds	2.205
"	tons (long)	9.842×10^{-4}
"	tons (short)	1.102×10^{-3}
kilograms/cu. meter	grams/cu. cm.	0.001
"	pounds/cu. ft.	0.06243
"	pounds/cu. in.	3.613×10^{-5}
"	pounds/mil.-foot	3.405×10^{-10}
kilograms/meter	pounds/ft.	0.6720
kilograms/sq. cm.	atmospheres	0.9678
"	feet of water	32.81
"	inches of mercury	28.96
"	pounds/sq. ft.	2,048.0
"	pounds/sq. in.	14.22
kilograms/sq. meter	atmospheres	9.678×10^{-5}
"	bars	98.07×10^{-6}
"	feet of water	32.81×10^{-3}
"	inches of mercury	2.896×10^{-3}
"	pounds/sq. ft.	0.2048
"	pounds/sq. in.	1.422×10^{-3}
kilograms/sq. mm.	kgs./sq. meter	10^6
kilogram-calories	Btu	3.968
"	foot-pounds	3,088.0
"	hp-hrs.	1.560×10^{-7}
"	joules	4,186.0
"	kg.-meters	426.9
"	kilojoules	4.186
"	kilowatt-hrs.	1.163×10^{-3}
kilogram meters	Btu	9.294×10^{-3}
"	ergs	9.804×10^7
"	foot-pounds	7.233
"	joules	9.804
"	kg.-calories	2.342×10^{-3}
"	kilowatt-hrs.	2.723×10^{-6}
kilolines	maxwells	10^3
kiloliters	liters	10^3
kilometers	centimeters	10^5
"	feet	3,281.0
"	inches	3.937×10^4
"	meters	10^3
"	miles	0.6214
"	millimeters	10^6
"	yards	1,094.0
kilometers/hr.	cms./sec.	27.78
"	feet/min.	54.68
"	feet/sec.	0.9113
"	knots	0.5396
"	meters/min.	16.67
"	miles/hr.	0.6214
kilometers/hrs./sec.	cms./sec./sec.	27.78
"	ft./sec./sec.	0.9113
"	meters/sec./sec.	0.2778
"	miles/hr./sec.	0.6214
kilopascals	atmospheres	9.87×10^{-3}
"	feet of water	0.335
"	inches of Hg	0.296
"	kgs/sq. meter	1.02×10^2
"	pounds/sq. ft.	20.9
"	pounds/sq. in.	0.145
"	torr	7.5
kilowatts	Btu/min.	56.92
"	foot-lbs./min.	4.426×10^4
"	foot-lbs./sec.	737.6

K (cont.)

TO CONVERT	INTO	MULTIPLY BY
kilowatts (cont.)	horsepower	1.341
"	kg.-calories/min.	14.34
"	watts	10^3
kilowatt-hrs.	Btu	3,413.0
"	ergs	3.600×10^{13}
"	foot-lbs.	2.655×10^6
"	gram-calories	859,850.0
"	horsepower-hrs.	1.341
"	joules	3.6×10^6
"	kg.-calories	860.5
"	kg.-meters	3.671×10^5
"	pounds of water evaporated from and at 212°F	3.53
"	pounds of water raised from 62° to 212°F	22.75
knots	feet/hr.	6,080.0
"	kilometers/hr.	1.8532
"	nautical miles/hr.	1.0
"	statute miles/hr.	1.151
"	yards/hr.	2,027.0
"	feet/sec.	1.689

L

league	miles (approx.)	3.0
lines/sq. cm.	gausses	1.0
lines/sq. in.	gausses	0.1550
"	webers/sq. cm.	1.550×10^{-9}
"	webers/sq. in.	10^{-8}
"	webers/sq. meter	1.550×10^{-5}
links (engineer's)	inches	12.0
links (surveyor's)	inches	7.92
liters	bushels (U.S. dry)	0.02838
"	cu. cm.	10^3
"	cu. feet	0.03531
"	cu. inches	61.02
"	cu. meters	0.001
"	cu. yards	1.308×10^{-3}
"	gallons (U.S. liq.)	0.2642
"	pints (U.S. liq.)	2.113
"	quarts (U.S. liq.)	1.057
liters/min.	cu. ft./sec.	5.886×10^{-4}
"	gals./sec.	4.403×10^{-3}
lumens/sq. ft.	foot-candles	1.0
lux	foot-candles	0.0929

M

maxwells	kilolines	10^{-3}
"	webers	10^{-8}
megalines	maxwells	10^6
megohms	microhms	10^{12}
"	ohms	10^6
meters	centimeters	10^2
"	feet	3.281
"	inches	39.37
"	kilometers	0.001
"	miles (naut.)	5.396×10^{-4}
"	miles (stat.)	6.214×10^{-4}
"	millimeters	10^3
"	yards	1.094
"	varas	1.179
meters/min.	cms./sec.	1.667
"	feet/min.	3.281
"	feet/sec.	0.5468
"	kms./hr.	0.06
"	knots	0.03238

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
M (cont.)		
meters/min. (cont.)	miles/hr.	0.03728
meters/sec.	feet/min.	196.8
"	feet/sec.	3.281
"	kilometers/hr.	3.6
"	miles/hr.	2.237
"	miles/min.	0.03728
meters/sec./sec.	cms./sec./sec.	10^{2}
"	ft./sec./sec.	3.281
"	kms./hr./sec.	3.6
"	miles/hr./sec.	2.237
meter-kilograms	cm.-dynes	9.807×10^{7}
"	cm.-grams	10^{5}
"	pound-feet	7.233
microfarad	farads	10^{-6}
micrograms	grams	10^{-6}
microhms	megohms	10^{-12}
"	ohms	10^{-6}
microliters	liters	10^{-6}
microns	meters	10^{-6}
miles (naut.)	feet	6,080.27
"	kilometers	1.853
"	meters	1,853.00
"	miles (statute)	1.1516
"	yards	2,027.0
miles (statute)	centimeters	1.609×10^{5}
"	feet	5,280.0
"	inches	6.336×10^{4}
"	kilometers	1.609
"	meters	1,609.0
"	miles (naut.)	0.8684
"	yards	1,760.0
miles/hr.	cm./sec.	44.70
"	feet/min.	88.0
"	feet/sec.	1.467
"	kms./hr.	1.609
"	kms./min.	0.02682
"	knots	0.8684
"	meters/min.	26.82
"	miles/min.	0.01667
miles/hr./sec.	cms./sec./sec.	44.70
"	feet/sec./sec.	1.467
"	kms./hr./sec.	1.609
"	meters/sec./sec.	0.4470
miles/min.	cms./sec.	2,682.0
"	feet/sec.	88.0
"	kms./min.	1.609
"	miles (naut.)/min.	0.8684
"	miles/hr.	60.0
mil-feet	cu. inches	9.425×10^{-6}
milliers	kilograms	10^{3}
milligrams	grams	10^{-3}
milligrams/liter	parts/million	1.0
millihenries	henries	10^{-3}
milliliters	liters	10^{-3}
millimeters	centimeters	0.1
"	feet	3.281×10^{-3}
"	inches	0.03937
"	meters	0.001
"	miles	6.214×10^{-7}
"	mils	39.37
"	yards	1.094×10^{-3}
million gals./day	cu. ft./sec.	1.54723
mils	centimeters	2.540×10^{-3}
"	feet	8.333×10^{-5}
"	inches	0.001
"	kilometers	2.540×10^{-8}

TO CONVERT	INTO	MULTIPLY BY
M (cont.)		
mils (cont.)	yards	2.778×10^{-5}
miner's inches	cu. ft./min.	1.5
minutes (angles)	degrees	0.01667
"	quadrants	1.852×10^{-4}
"	radians	2.909×10^{-4}
"	seconds	60.0 myriagrams
	kilograms	10.0
myriameters	kilometers	10.0
myriawatts	kilowatts	10.0
N		
nepers	decibels	8.686
O		
ohms	megohms	10^{-6}
ohms	microhms	10^{6}
ounces	drams	16.0
"	grains	437.5
"	grams	28.349527
"	pounds	0.0625
"	ounces (troy)	0.9115
"	tons (long)	2.790×10^{-5}
"	tons (metric)	2.834×10^{-5}
ounces (fluid)	cu. inches	1.805
"	liters	0.2957
ounces (troy)	grains	480.0
"	grams	31.103481
"	ounces (avdp.)	1.09714
"	pennyweights (troy)	20.0
"	pounds (troy)	0.08333
ounces/sq. in.	pounds/sq. in.	0.0625
P		
parts/million	grains/U.S. gal.	0.0584
"	grains/Imp. gal.	0.07016
"	pounds/million gal.	8.345
pascals	millibar	10^{-2}
"	pounds/sq. ft.	2.09×10^{-2}
"	pounds/sq. in.	1.45×10^{-4}
"	torr	7.5×10^{-3}
"	in.Hg	2.96×10^{-4}
pennyweights (troy)	grains	24.0
"	ounces (troy)	0.05
"	grams	1.55517
"	pounds (troy)	4.1667×10^{-3}
pints (dry)	cu. inches	33.60
pints (liq.)	cu. cms.	473.2
"	cu. feet	0.01671
"	cu. inches	28.87
"	cu. meters	4.732×10^{-4}
"	cu. yards	6.189×10^{-4}
"	gallons	0.125
"	liters	0.4732
"	quarts (liq.)	0.5
poundals	dynes	13,826.0
"	grams	14.10
"	joules/cm.	1.383×10^{-3}
"	joules/meter (newtons)	0.1383
"	kilograms	0.01410
"	pounds	0.03108
pounds	drams	256.0
"	dynes	44.4823×10^{4}
"	grains	7,000.0
"	grams	453.5924
"	joules/cm.	0.04448
"	joules/meter (newton)	4.448

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
P (cont.)		
pounds (cont.)	kilograms	0.4536
"	ounces	16.0
"	ounces (troy)	14.5833
"	poundals	32.17
"	pounds (troy)	1.21528
"	tons (short)	0.0005
pounds (troy)	grains	5,760.0
"	grams	373.24177
"	ounces (avdp.)	13.1657
"	ounces (troy)	12.0 pounds (troy)
"	pennyweights (troy)	240.0
"	pounds (avdp.)	0.822857
"	tons (long)	3.6735×10^{-4}
"	tons (metric)	3.7324×10^{-4}
"	tons (short)	4.1143×10^{-4}
pounds of water	cu. feet	0.01602
"	cu. inches	27.68
"	gallons	0.1198
pounds of water/min.	cu. ft./sec.	2.670×10^{-4}
pounds-feet	cm.-dynes	1.356×10^{7}
"	cm.-grams	13,825.0
"	meter-kgs.	0.1383
pounds/cu. ft.	grams/cu. cm.	0.01602
"	kgs./cu. meter	16.02
"	pounds/cu. in.	5.787×10^{-4}
"	pounds/mil.-ft.	5.456×10^{-9}
pounds/cu. in.	gms./cu. cm.	27.68
"	kgs./cu. meter	2.768×10^{4}
"	pounds/cu. ft.	1,728.0
"	pounds/mil.-foot	9.425×10^{-6}
pounds/ft.	kgs./meter	1.488
pounds/in.	gms./cm.	178.6
pounds/mil.-foot	gms./cu. cm.	2.306×10^{6}
pounds/sq. ft.	atmospheres	4.725×10^{-4}
"	feet of water	0.01602
"	inches of mercury	0.01414
"	kgs./sq. meter	4.882
"	pounds/sq. in.	6.944×10^{-3}
pounds/sq. in.	atmospheres	0.06804
"	feet of water	2.307
"	inches of mercury	2.036
"	kgs./sq. meter	703.1
"	pounds/sq. ft.	144.0
"	kilopascal	6.8948
Q		
quadrants (angle)	degrees	90.0
"	minutes	5,400.0
"	radians	1.571
"	seconds	3.24×10^{5}
quarts (dry)	cu. inches	67.20
quarts (liq.)	cu. cms.	946.4
"	cu. feet	0.03342
"	cu. inches	57.75
"	cu. meters	9.464×10^{-4}
"	cu. yards	1.238×10^{-3}
"	gallons	0.25
"	liters	0.9463
R		
radians	degrees	57.30
"	minutes	3,438.0
"	quadrants	0.6366
"	seconds	2.063×10^{5}
radians/sec.	degrees sec.	57.30
"	revolutions/min.	9.549

TO CONVERT	INTO	MULTIPLY BY
R (cont.)		
radians/sec. (cont.)	revolutions/sec.	0.1592
radians/sec./sec.	revs./min./min.	573.0
"	revs./min./sec.	9.549
"	revs./sec./sec.	0.1592
revolutions	degrees	360.0
"	quadrants	4.00
"	radians	6.283
revolutions/min.	degrees/sec.	6.0
"	radians/sec.	0.1047
"	revs./sec.	0.01667
revolutions/min./min.	radians/sec./sec.	1.745×10^{-3}
"	revs./min./sec.	0.01667
"	revs./sec./sec.	2.778×10^{-4}
revolutions/sec.	degrees/sec.	360.0
"	radians/sec.	6.283
"	revs./min.	60.0
revolutions/sec./sec.	radians/sec./sec.	6.283
"	revs./min./min.	3,600.0
"	revs./min./sec.	60.0
rods	feet	16.5
S		
seconds (angle)	degrees	2.778×10^{-4}
"	minutes	0.01667
"	quadrants	3.087×10^{-6}
"	radians	4.848×10^{-6}
square centimeters	circular mils	1.973×10^{5}
"	sq. feet	1.076×10^{-3}
"	sq. inches	0.1550
"	sq. meters	0.0001
"	sq. miles	3.861×10^{-11}
"	sq. millimeters	100.0
"	sq. yards	1.196×10^{-4}
square feet	acre	2.296×10^{-5}
"	circular mils	1.833×10^{8}
"	sq. cms.	929.0
"	sq. inches	144.0
"	sq. meters	0.09290
"	sq. miles	3.587×10^{-8}
"	sq. millimeters	9.290×10^{4}
"	sq. yards	0.1111
square inches	circular mils	1.273×10^{6}
"	sq. cms.	6.452
"	sq. feet	6.944×10^{-3}
"	sq. millimeters	645.2
"	sq. mils	10^{6}
"	sq. yards	7.716×10^{-4}
square kilometers	acres	247.1
"	sq. cms.	10^{10}
"	sq. ft.	10.76×10^{6}
"	sq. inches	1.550×10^{9}
"	sq. meters	10^{6}
"	sq. miles	0.3861
"	sq.yards	1.196×10^{6}
square meters	acres	2.471×10^{-4}
"	sq. cms.	10^{4}
"	sq. feet	10.76
"	sq. inches	1,550.0
"	sq. miles	3.861×10^{-7}
"	sq. millimeters	10^{6}
"	sq. yards	1.196
square miles	acres	640.0
"	sq. feet	27.88×10^{6}
"	sq. kms.	2.590
"	sq. meters	2.590×10^{6}
"	sq. yards	3.098×10^{6}

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
S (cont.)		
square millimeters	circular mils	1,973.0
"	sq. cms.	0.01
"	sq. feet	1.076×10^{-5}
"	sq. inches	1.550 x 10-C
square mils	circular mils	1.273
"	sq. cms.	6.452×10^{-6}
"	sq. inches	10^{-6}
square yards	acres	2.066×10^{-4}
"	sq. cms.	8,361.0
"	sq. ft.	9.0
"	sq. inches	1,296.0
"	sq. meters	0.8361
"	sq. miles	3.228×10^{-7}
"	sq. millimeters	8.361×10^{5}
T		
temperature (°C) + 273	absolute temperature (°C)	1.0
temperature (°C) + 17.78	temperature (°F)	1.8
temperature (°F) + 460	absolute temperature (°F)	1.0
temperature (°F) - 32	temperature (°C)	0.555
tons (long)	kilograms	1,016.0
"	pounds	2,240.0
"	tons (short)	1.120
tons (metric)	kilograms	1,000.0
"	pounds	2,205.0
tons (short)	kilograms	907.1848
"	ounces	32,000.0
"	ounces (troy)	29,166.66
"	pounds	2,000.0
"	pounds (troy)	2,430.56
"	tons (long)	0.89287
"	tons (metric)	0.9078
tons (short)/sq. ft.	kgs./sq. meter	9,765.0
"	pounds/sq. in.	2,000.0
tons of water/24 hrs.	pounds of water/hr.	83.333
"	gallons/min.	0.16643
"	cu. ft./hr.	1.3349

TO CONVERT	INTO	MULTIPLY BY
W		
watts	Btu/hr.	3.4192
"	Btu/min.	0.05688
"	ergs/sec.	107.0
"	foot-lbs./min.	44.27
"	foot-lbs./sec.	0.7378
"	horsepower	1.341×10^{-3}
"	horsepower (metric)	1.360×10^{-3}
"	kg.-calories/min.	0.01433
"	kilowatts	0.001
watt-hours	Btu	3.413
"	ergs	3.60×10^{10}
"	foot-pounds	2,656.0
"	gram-calories	859.85
"	horsepower-hrs.	1.341×10^{-3}
"	kilogram-calories	0.8605
"	kilogram-meters	367.2
"	kilowatt-hrs.	0.001
webers	maxwells	10^{8}
"	kilolines	10^{5}
webers/sq. in.	gausses	1.550×10^{7}
"	lines/sq. in.	10^{8}
"	webers/sq. cm.	0.1550
"	webers/sq. meter	1,550.0
webers/sq. meter	gausses	10^{4}
"	lines/sq. in.	6.452×10^{4}
"	webers/sq. cm.	10^{-4}
"	webers/sq. in.	6.452×10^{-4}
Y		
yards	centimeters	91.44
"	feet	3.0
"	inches	36.0
"	kilometers	9.144×10^{-4}
"	meters	0.9144
"	miles (naut.)	4.934×10^{-4}
"	miles (stat.)	5.682×10^{-4}
"	millimeters	914.4

Equivalents: Liquid Measures and Weights

TO OBTAIN / MULTIPLY BY	U.S. Gallon	Imperial Gallon	U.S. Pint	U.S. Pound Water*	U.S. Cubic Foot	U.S. Cubic Inch	Liter	Cubic Meter
U.S. Gallon	1	0.833	8.0	8.337	0.13368	231.0	3.78533	0.003785
Imperial Gallon	1.2009	1	9.60762	10.0	0.16054	277.42	4.54596	0.004546
U.S. Pint	0.125	0.1041	1	1.042	0.01671	28.875	0.473166	0.000473
U.S. Pound Water*	0.11995	0.1	0.9596	1	0.016035	27.708	0.45405	0.000454
U.S. Cubic Foot	7.48052	6.22888	59.8442	62.365	1	1728.0	28.31702	0.028317
U.S. Cubic Inch	0.004329	0.00361	0.034632	0.03609	0.0005787	1	0.016387	0.0000164
Liter	0.2641779	0.2199756	2.113423	2.202	0.0353154	61.02509	1	0.001000
Cubic Meter	264.170	219.969	2113.34	2202.0	35.31446	61023.38	999.972	1

*Water at 60°F (15.6°C)
1 Barrel = 42 gallons (petroleum measure)

EXAMPLE:
(8 Imperial gallons) (4.54596) = 36.36768 liters

Equivalents: Kinematic Viscosity

To convert kinematic viscosity from one set of units to another, locate the given set of units in the left hand column and multiply the numerical value by the factor shown horizontally to the right, under the set of units desired.

As an example, suppose a given kinematic viscosity of 0.5 square foot/second is to be converted to centistokes. By referring to the table, we find the conversion factor to be 92,900. Then, 0.5 (sq ft/sec) times 92,900 = 46,450 centistokes.

Kinematic Viscosity		centistokes (ν)	stokes $\frac{cm^2}{sec}$ ($100\ \nu$)	$\frac{ft^2}{sec}$ (ν')
centistokes	(ν)	1	0.01	$1.076\ (10^{-5})$
stokes $\frac{cm^2}{sec}$	($100\ \nu$)	100	1	$1.076\ (10^{-3})$
$\frac{ft^2}{sec}$	(ν')	92,900	929	1

Equivalents: Absolute (Dynamic) Viscosity

To convert absolute or dynamic viscosity from one set of units to another, locate the given set of units in the left hand column and multiply the numerical value by the factor shown horizontally to the right under the set of units desired.

As an example, suppose a given absolute viscosity of 2 poise is to be converted to N s/m^2. By referring to the table the conversion factor is 0.1. Thus 2 Poise is equal to 2 times 0.1, which is equal to 0.2 N s/m^2.

MULTIPLY BY						
CONVERT FROM	**CONVERT TO**					
	Poiseuille (Pa s)	**Poise (dyne s/cm^2) (g/cm s)**	**N s/m^2**	**centiPoise**	**kg$_f$ s/m^2**	**kg/m h**
Poiseuille (Pa s)	1	10	1	1000	0.102	3600
Poise (dyne s/cm^2) (g/cm s)	0.1	1	0.1	100	0.0102	360
N s/m^2	1	10	1	1000	0.102	3600
centiPoise	0.001	0.01	0.001	1	0.000102	3.6
kg$_f$ s/m^2	9.81	98.1	9.807	9807	1	35.304
slugs/ftsec (lb s/ft^2)	47.9	479	47.9	4.79×10^4	4.882	1.72×10^5
lb/ft s	1.49	14.9	1.488	1,488	0.152	5,357

Equivalents: Electrical Units

	Practical Unit	**Cgs Electromagnetic Unit**	**Cgs Electrostatic Unit**
Emf	volt = 10^8 abvolts volt = 3.3×10^{-3} statvolt	abvolt = 10^{-8} volt abvolt = 3.3×10^{-11} statvolt	statvolt = 300 volts (approx.) statvolt = 3×10^{10} abvolts
Resistance	ohm = 10^9 abohms ohm = 1.1×10^{-12} statohm	abohm = 10^{-9} ohm abohm = 1.1×10^{-21} statohm	statohm = 9×10^{11} ohms statohm = 9×10^{20} abohms
Current	ampere = 10^{-1} abampere ampere = 3×10^9 statamperes	abampere = 10 amperes abampere = 3×10^{10} statamperes	statampere = 3.3×10^{-10} ampere statampere = 3.3×10^{-11} abampere
Quantity	coulomb = 10^{-1} abcoulomb coulomb = 3×10^9 statcoulombs	abcoulomb = 10 coulombs abcoulomb = 3×10^{10} statcoulombs	statcoulomb = 3.3×10^{-10} coulomb statcoulomb = 3.3×10^{-11} abcoulombs
Capacitance	farad = 10^{-9} abfarads farad = 9×10^{11} statfarads	abfarad = 10^9 farads abfarad = 9×10^{20} statfarads	statfarad = 1.1×10^{-12} farads statfarad = 1.1×10^{-21} abfarads
Inductance	henry = 10^9 abhenries henry = 1.1×10^{-12} stathenry	abhenry = 10^{-9} henry abhenry = 1.1×10^{-21} stathenries	stathenry = 9×10^{11} henries stathenry = 9×10^{20} abhenries
Energy	joule = 10^7 ergs	erg = 10^{-7} joule	erg = 10^{-7} joule
Power	watt = 10^7 $\frac{\text{ergs}}{\text{sec}}$	$\frac{\text{erg}}{\text{sec}} = 10^{-7}$ watt	$\frac{\text{erg}}{\text{sec}} = 10^{-7}$ watt

Equivalents: Degrees API and Degrees Baumé

Degrees on API or Baumé Scale	Values for API Scale Oil			Values for Baumé Scale					
				Liquids Lighter Than Water			Liquids Heavier Than Water		
	Specific Gravity S	Weight Density Lb/Ft³ p	Pounds per Gallon	Specific Gravity S	Weight Density Lb/Ft³ p	Pounds per Gallon	Specific Gravity S	Weight Density Lb/Ft³ p	Pounds per Gallon
0	–	–	–	–	–	–	1.0000	62.36	8.337
2	–	–	–	–	–	–	1.0140	63.24	8.454
4	–	–	–	–	–	–	1.0284	64.14	8.574
6	–	–	–	–	–	–	1.0432	65.06	8.697
8	–	–	–	–	–	–	1.0584	66.01	8.824
10	1.0000	62.36	8.337	1.0000	62.36	8.337	1.0741	66.99	8.955
12	0.9861	61.50	8.221	0.9859	61.49	8.219	1.0902	67.99	9.089
14	0.9724	60.65	8.108	0.9722	60.63	8.105	1.1069	69.03	9.228
16	0.9593	59.53	7.998	0.9589	59.80	7.994	1.1240	70.10	9.371
18	0.9465	59.03	7.891	0.9459	58.99	7.886	1.1417	71.20	9.518
20	0.9340	58.25	7.787	0.9333	58.20	7.781	1.1600	72.34	9.671
22	0.9218	57.87	7.736	0.9211	57.44	7.679	1.1789	73.52	9.828
24	0.9100	56.75	7.587	0.9091	56.70	7.579	1.1983	74.73	9.990
26	0.8984	56.03	7.490	0.8974	55.97	7.482	1.2185	75.99	10.159
28	0.8871	55.32	7.396	0.8861	55.26	7.387	1.2393	77.29	10.332
30	0.8762	54.64	7.305	0.8750	54.57	7.295	1.2609	78.64	10.512
32	0.8654	53.97	7.215	0.8642	53.90	7.205	1.2832	80.03	10.698
34	0.8550	53.32	7.128	0.8537	53.24	7.117	1.3063	81.47	10.891
36	0.8448	52.69	7.043	0.8434	52.60	7.031	1.3303	82.96	11.091
38	0.8348	52.06	6.960	0.8333	51.97	6.947	1.3551	84.51	11.297
40	0.8251	51.46	6.879	0.8235	51.36	6.865	1.3810	86.13	11.513
42	0.8155	50.86	6.799	0.8140	50.76	6.786	1.4078	87.80	11.737
44	0.8063	50.28	6.722	0.8046	50.18	6.708	1.4356	89.53	11.969
46	0.7972	49.72	6.646	0.7955	49.61	6.632	1.4646	91.34	12.210
48	0.7883	49.16	6.572	0.7865	49.05	6.557	1.4948	93.22	12.462
50	0.7796	48.62	6.499	0.7778	48.51	6.484	1.5263	95.19	12.725
52	0.7711	48.09	6.429	0.7692	47.97	6.413	1.5591	97.23	12.998
54	0.7628	47.57	6.359	0.7609	47.45	6.344	1.5934	99.37	13.284
56	0.7547	47.07	6.292	0.7527	46.94	6.275	1.6292	101.60	13.583
58	0.7467	46.57	6.225	0.7447	46.44	6.209	1.6667	103.94	13.895
60	0.7389	46.08	6.160	0.7368	45.95	6.143	1.7059	106.39	14.222
62	0.7313	45.61	6.097	0.7292	45.48	6.079	1.7470	108.95	14.565
64	0.7238	45.14	6.034	0.7216	45.00	6.016	1.7901	111.64	14.924
66	0.7165	44.68	5.973	0.7143	44.55	5.955	1.8354	114.46	15.302
68	0.7093	44.23	5.913	0.7071	44.10	5.895	1.8831	117.44	15.699
70	0.7022	43.79	5.854	0.7000	43.66	5.836	1.9333	120.57	16.118
72	0.6953	43.36	5.797	0.6931	43.22	5.788	–	–	–
74	0.6886	42.94	5.741	0.6863	42.80	5.722	–	–	–
76	0.6819	42.53	5.685	0.6796	42.38	5.666	–	–	–
78	0.6754	42.12	5.631	0.6731	41.98	5.612	–	–	–
80	0.6690	41.72	5.577	0.6667	41.58	5.558	–	–	–
82	0.6628	41.33	5.526	0.6604	41.19	5.506	–	–	–
84	0.6566	40.95	5.474	0.6542	40.80	5.454	–	–	–
86	0.6506	40.57	5.424	0.6482	40.42	5.404	–	–	–
88	0.6446	40.20	5.374	0.6422	40.05	5.354	–	–	–
90	0.6388	39.84	5.326	0.6364	39.69	5.306	–	–	–
92	0.6331	39.48	5.278	0.6306	39.33	5.257	–	–	–
94	0.6275	39.13	5.231	0.6250	38.98	5.211	–	–	–
96	0.6220	38.79	5.186	0.6195	38.63	5.165	–	–	–
98	0.6166	38.45	5.141	0.6140	38.29	5.119	–	–	–
100	0.6112	38.12	5.096	0.6087	37.96	5.075	–	–	–

Equivalents: Kinematic and Saybolt Viscosity

Equivalents of Kinematic and Saybolt Furol Viscosity

Kinematic Viscosity, Centistokes v	Equivalent Saybolt Furol Viscosity, Sec	
	At 122°F (50°C) Basic Values	At 210°F (99°C)
48	25.3	
50	26.1	25.2
60	30.6	29.8
70	35.1	34.4
80	39.6	39.0
90	44.1	43.7
100	48.6	48.3
125	60.1	60.1
150	71.7	71.8
175	83.8	83.7
200	95.0	95.6
225	106.7	107.5
250	118.4	119.4
275	130.1	131.4
300	141.8	143.5
325	153.6	155.5
350	165.3	167.6
375	177.0	179.7
400	188.8	191.8
425	200.6	204.0
450	212.4	216.1
475	224.1	228.3
500	235.9	240.5
525	247.7	252.8
550	259.5	265.0
575	271.3	277.2
600	283.1	289.5
625	294.9	301.8
650	306.7	314.1
675	318.4	326.4
700	330.2	338.7
725	342.0	351.0
750	353.8	363.4
775	365.5	375.7
800	377.4	388.1
825	389.2	400.5
850	400.9	412.9
875	412.7	425.3
900	424.5	437.7
925	436.3	450.1
950	448.1	462.5
975	459.9	474.9
1000	471.7	487.4
1024	483.5	499.8
1050	495.2	512.3
1075	507.0	524.8
1100	518.8	537.2
1125	530.6	549.7
1150	542.4	562.2
1175	554.2	574.7
1200	566.0	587.2
1225	577.8	599.7
1250	589.9	612.2
1275	601.3	624.8
1300	613.1	637.3
Over 1300	Saybolt Furol Seconds = Centistokes x 0.4717	Log (Saybolt Furol Seconds - 2.87) = 1.0276 [Log (Centistokes)] - 0.3975

Equivalents of Kinematic and Saybolt Universal Viscosity

Kinematic Viscosity, Centistokes v	Equivalent Saybolt Universal Viscosity, Sec	
	At 100°F (37.8°C) Basic Values	At 210°F (99°C)
1.83	32.01	32.23
2.0	32.62	32.85
4.0	39.14	39.41
6.0	45.56	45.88
8.0	52.09	52.45
10.0	58.91	59.32
15.0	77.39	77.93
20.0	97.77	98.45
25.0	119.3	120.1
30.0	141.3	142.3
35.0	163.7	164.9
40.0	186.3	187.6
45.0	209.1	210.5
50.0	232.1	233.8
55.0	255.2	257.0
60.0	278.3	280.2
65.0	301.4	303.5
70.0	324.4	326.7
75.0	347.6	350.0
80.0	370.8	373.4
85.0	393.9	396.7
90.0	417.1	420.0
95.0	440.3	443.4
100.0	463.5	466.7
120.0	556.2	560.1
140.0	648.9	653.4
160.0	741.6	
180.0	834.2	
200.0	926.9	
220.0	1019.6	
240.0	1112.3	
250.0	1205.0	
280.0	1297.7	
300.0	1390.4	
320.0	1483.1	
340.0	1575.8	
360.0	1668.5	Saybolt Seconds = Centistokes x 4.6673
380.0	1761.2	
400.0	1853.9	
420.0	1946.6	
440.0	2039.3	
460.0	2132.0	
480.0	2224.7	
500.0	2317.4	
Over 500	Saybolt Seconds = Centistokes x 4.6347	

Note: To obtain the Saybolt Universal viscosity equivalent to a kinematic viscosity determined at t, multiply the equivalent Saybolt Universal viscosity at 100°F (37.8°C) by $1+(t - 100)\ 0.000\ 064$.

For example, 10 v at 210°F (99°C) are equivalent to 58.91 multiplied by 1.0070 or 59.32 sec Saybolt Universal at 210°F (99°C).

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To convert from one set of units to another, locate the given unit in the left hand column, and multiply the numerical value by the factor shown horizontally to the right, under the set of units desired.

TO OBTAIN / MULTIPLY BY	lb/in²	lb/ft²	Atmospheres	kg/cm²	kg/m²	in. water (68°F)*	ft. water (68°F)*	in. mercury (32°F)†	mm mercury (32°F)†	Bars ‡	Mega-Pascals (MPa)‡	kPa	mm water (68°F)
lb/in.²	1	144.0	0.068046	0.070307	703.070	27.7300	2.3108	2.03602	51.7149	0.068948	0.0068948	6.8948	704.342
lb/ft.²	0.0069444	1	0.000473	0.000488	4.88243	0.019257	0.016048	0.014139	0.35913	0.0004788	0.0000479	0.04788	4.89127
Atmospheres	14.696	2116.22	1	1.0332	10332.0	407.520	33.9600	29.921	760.00	1.01325	0.101325	101.325	10351.0
kg/cm²	14.2233	2048.16	0.96784	1	10000.0	394.41	32.868	28.959	735.558	0.98066	0.098066	98.066	10018.1
kg/m²	0.001422	0.204816	0.0000968	0.0001	1	0.03944	0.003287	0.002896	0.073556	0.000098	0.0000098	0.0098	1.00181
in./water*	0.036062	5.1929	0.002454	0.00253	25.354	1	0.08333	0.073423	1.8649	0.002486	0.000249	0.24864	25.4
ft./water*	0.432744	62.315	0.029446	0.030425	304.249	12.0	1	0.88108	22.3793	0.29837	0.0029837	2.9837	304.800
in. mercury†	0.491154	70.7262	0.033420	0.03453	345.319	13.6197	1.1350	1	25.4	0.033864	0.0033864	3.3864	345.94
mm mercury†	0.0193368	2.78450	0.0013158	0.0013595	13.595	0.53621	0.044684	0.03937	1	0.001333	0.0001333	0.13332	13.6197
Bars‡	14.5038	2088.54	0.98692	1.01972	10197.2	402.190	33.5158	29.5300	750.061	1	0.10	100.0	10215.6
MPa‡	145.038	20885.4	9.8692	10.1972	101972.0	4021.90	335.158	295.300	7500.61	10.0	1	1000.0	102156.0
kPa	0.145038	20.8854	0.0098692	0.0101972	101.972	4.02190	0.33516	0.2953	7.50061	0.01	0.001	1	102.156
mm water column	.0014198	.20445	.0000966	.0000998	.99819	.039370	.003281	.002891	.073423	.0000979	.0000098	.0097889	1

*Water at 68°F (20°C) †mercury at 32°F (0°C) ‡MPa (MegaPascal) = 10 Bars = 1,000,000 N/m² (Newtons/meter²)

EXAMPLE:

(5 kg/cm²) (2048.16) = 10,240.8 lb./ft.²

Properties: Density and Specific Gravity of Selected Liquids

Liquid	Temperature		Density①	Specific②
	°F	°C	lb/ft³	Gravity
Acetaldehyde	64	17.8	38.9	0.8
Acetone	60	15.6	49.4	0.8
Acetic Anhydride	68	20.0	67.5	1.1
Acid, Acetic Conc.	68	20.0	65.5	1.1
Acid, Benzoic	59	15.0	79.0	1.3
Acid, Butyric, Conc.	68	20.0	60.2	1.0
Acid, Hydrochloric, 42.5%	64	17.8	92.3	1.4
Acid, Hydrocyanic	64	17.8	43.5	0.8
Acid, Nitric, Conc. Boil.	64	17.8	93.7	1.5
Acid, Ortho-phosphoric	65	18.3	114.4	1.8
Ammonia, Saturated	10	-12.2	40.9	0.7
Aniline	68	20.0	63.8	1.0
Argon	60	15.6	102.9	1.7
Asphalt	75	23.9	61.1	1.0
Beer	60	15.6	63.0	1.0
Benzene	32	0.0	56.1	0.9
Brine, 10% CaCl	32	0.0	68.1	1.1
Brine, 10% NaCl	32	0.0	67.2	1.1
Bromine	60	15.6	182.7	3.0
Bunkers C Fuel Max	60	15.6	63.3	1.0
Butane-n	60	15.6	36.4	0.6
Carbon Disulphide	32	0.0	80.6	1.3
Carbon Monoxide	60	15.6	49.9	0.8
Carbon Tetrachloride	68	20.0	99.6	1.6
China Wood Oil	60	15.6	58.8	1.0
Chloride	77	25.0	97.3	1.6
Chlorobenzene	68	20.0	69.1	1.1
Chloroform	68	20.0	92.9	1.5
Chromic Acid	60	15.6	75.5	1.2
Citric Acid	60	15.6	96.1	1.5
Cocoanut Oil	60	15.6	57.9	0.9
Corn syrup 86.4 Brix	60	15.6	91.1	1.5
Corn syrup 78.4 Brix	60	15.6	87.9	1.4
Creosote	60	15.6	66.7	1.1
Cresol, Meta	68	20.0	64.5	1.0
Decane-n	60	15.6	45.5	0.7
Diesel Fuel grade 1-D	60	15.6	51.5	0.8
Diesel Fuel grade 2-D	60	15.6	54.0	0.9
Diesel Fuel grade 4-D	60	15.6	57.3	0.9
Diphenyl	163	72.8	61.9	1.0
Distallate	60	15.6	63.0	0.9
Dowtherm A	700	371.1	45.5	0.7
Ethanol	77	25.0	48.6	0.8
Ether	77	25.0	44.7	0.7
Ethyl Acetate	68	20.0	56.1	0.9
Ethyl Alcohol	77	25.0	49.1	0.8
Ethylamine	61	16.1	42.6	0.7
Ethyl Benzene	68	20.0	53.6	0.9
Ethyl Chloride	68	20.0	78.0	1.3
Ethyl Oxide	30	-1.1	54.9	0.9
Ethylene Glycol	60	15.6	70.5	1.1
Fluorine	60	15.6	69.7	1.1
Formaldehyde	113	45.0	50.8	0.8
Formic Acid	100	37.8	56.1	0.9
Fuell 3 Max	60	15.6	56.0	0.9
Fuel 5 Min	60	15.6	60.2	1.0
Fuel 5 Max	60	15.6	61.9	1.0
Fuel 6 Min	60	15.6	61.9	1.0
Fuel Oil (Bunker C)	59	15.6	62.3	1.0
Furfural	68	20.0	72.3	1.2
Gasoline	60	15.6	46.8	0.8
Gasoline, Natural	60	15.6	42.4	0.7
Glucose	60	15.6	87.3	1.4
Glycerol (Glycerine)	122	50.0	78.6	1.3
Glycol	68	20.0	69.2	1.1
Helium	60	15.6	8.7	0.1
Heptane	68	20.0	42.7	0.7
Heptane-n	60	15.6	42.9	0.7
Hexane-n	60	15.6	41.4	0.7
Hexanol	77	25.0	50.7	0.8
Hydrofluoric Acid	60	15.6	57.4	0.9
Hydrogen Chloride	60	15.6	53.6	0.9
Hydrogen Sulfide	60	15.6	49.3	0.8
Ink, printers	60	15.6	74.8	1.2
Ionene	77	25.0	58.3	0.9
Isobutyl Alcohol	68	20.0	50.5	0.8
Isopropyl Alcohol	68	20.0	49.9	0.8
Jet Fuel, grade JP-4	60	15.6	53.0	0.7
Kerosene	60	15.6	50.8	0.8
Lard	60	15.6	59.9	1.0
Lard Oil	60	15.6	57.4	0.9
Linolenic Acid	77	25.0	56.3	0.9
Linseed Oil	60	15.6	58.0	0.9
M. C. Residuum	60	15.6	58.3	0.9
Mercury	20	-6.7	849.7	13.6
Mercury	40	4.4	848.0	13.6
Mercury	60	15.6	846.3	13.6
Mercury	80	26.7	844.6	13.5
Mercury	100	37.8	842.9	13.5
Methane	-2.66	-16.3	29.1	0.5
Methyl Alcohol	77	25.0	49.2	0.8
Methylene Chloride	68	20.0	83.4	1.3
Methyl Ethyl Ketone	72	22.2	49.9	0.8
Methyl Propyl	58	14.4	50.5	0.8
Milk	60	15.6	64.8	1.0
Mineral Oil	80	26.7	56.1	0.9
Naphtha, Petroleum	59	15.0	41.6	0.7
Naphtha, Wood	77	25.0	43.7	0.7
Naphthalene	77	25.0	60.1	1.0
Nonane-n	60	15.6	64.8	1.0
Nonanol	77	25.0	51.3	0.8
Ocimene	77	25.0	49.9	0.8
Octane-n	60	15.6	44.1	0.7
Oil, Olive	69	15.0	57.3	0.9
Palmitic Acid	77	25.0	53.2	0.9
Pentane	59	15.0	38.9	0.6
Petroleum Ether	60	15.6	39.9	0.6
Phenol	77	25.0	66.8	1.1
Phosgene	32	0	86.1	1.4
Phosphorus	93	33.9	108.5	1.7
Propane	0	-17.7	30.1	0.5
Propanol	77	25.0	50.3	0.8
Propyl Alcohol	77	25.0	50.0	0.8
Propylene	77	25.0	32.2	0.5
Propylene Glycol	77	25.0	60.4	1.0
Pyridine	68	20.0	61.3	1.0
Resorcinol	77	25.0	79.3	1.3
Rosin Oil	60	15.6	61.1	1.0
Sabiname	77	25.0	50.8	0.8
SAE 10 Lube	60	15.6	54.6	0.9
SAE 30 Lube	60	15.6	56.0	0.9
SAE 70 Lube	60	15.6	57.1	0.9
Salt Creek Crude	60	15.6	53.8	0.9
Silane	77	25.0	44.8	0.7
Sorbaldehyde	77	25.0	56.0	0.9
Sperm Oil	60	15.6	86.7	1.4
Starch	60	15.6	93.6	1.5
Stearic Acid	77	25.0	58.7	0.9
Styrene	77	25.0	56.5	0.9
Sucrose 60 Brix	60	15.6	80.5	1.3
Sucrose 76 Brix	60	15.6	86.7	1.4
Sulphur Dioxide	32	0.0	89.2	1.4
Sulphuric Acid	68	20.0	116.0	1.9
Sulphuric Acid	60	15.6	114.1	1.8
Sulphur Trioxide	70	21.1	119.8	1.9
32.6° API Crude	60	15.6	53.8	0.9
35.6° API Crude	60	15.6	52.8	0.8
40° API Crude	60	15.6	51.4	0.8
48° API Crude	60	15.6	49.2	0.8
Tar, Road RT-4	60	15.6	67.4	1.1
Tar, Road RT-8	60	15.6	70.5	1.1
Tar, Road RT-12	60	15.6	71.7	1.2
Terpinene	212	100.0	53.0	0.9
Toluene (Toluol)	68	20.0	54.1	0.9
Transmission Oil	80	26.7	58.6	0.9
Trichloroethylene	68	20.0	91.5	1.5
Turpentine	60	15.6	53.9	0.9
Varnish, spar	60	15.6	56.1	0.9
Vegetable Oil	60	15.6	56.8	0.9
Water	60	15.6	62.4	1.0
Water	100	37.8	61.9	1.0
Water, Distilled	70	21.1	61.7	1.0
Water, sea	60	15.6	64.2	1.0
Whale Oil	60	15.6	57.7	0.9
Xylol (Xylene)	68	20.0	55.0	0.9

① Density is shown for the temperature listed.

② Specific gravity uses water at 60°F as base conditions.

Properties: Density and Specific Gravity of Selected Gases

Gas	Chemical Formula	Molecular Weight	Density① lb/ft³	Density② kg/m³	Specific② Gravity	Critical Temperature
Acetylene	C_2H_2	26.04	0.0673	1.1459	0.899	95
Air	–	28.96	0.0748	1.2740	1.000	-220
Ammonia	NH_3	17.03	0.0440	0.7491	0.588	270
Argon	Ar	39.95	0.1032	1.7572	1.379	-188
Bio Gas (65% Methane, 35% CO_2)	–	25.83	0.0668	1.1363	0.892	-116
Butane-N	C_4H_{10}	58.12	0.1502	2.5567	2.007	305
Butylene	C_4H_8	56.11	0.1450	2.4681	1.937	306
Carbon Dioxide	CO_2	44.11	0.1137	1.9359	1.520	90
Carbon Monoxide	CO	28.01	0.0724	1.2321	0.967	-222
Chlorine	Cl_2	70.91	0.1833	3.1205	2.499	291
Ethane	C_2H_6	30.07	0.0777	1.3227	1.038	90
Ethylene	C_2H_4	28.05	0.0725	1.2340	0.969	49
Helium	He	4.00	0.0103	0.1761	0.138	-450
Hexane, Average	C_6H_{14}	86.18	0.2227	3.7908	2.976	454
Hydrogen	H_2	2.02	0.0052	0.0887	0.070	-402
Hydrogen Sulfide	H_2S	34.08	0.0881	1.4997	2.125	213
Methane	CH_4	16.04	0.0415	0.7057	0.554	-117
Nitric Oxide	NO	30.00	0.0776	1.3202	1.071	-135
Nitrogen	N_2	28.01	0.0724	1.2323	0.967	-233
Nitrous Oxide	N_2O	44.01	0.1138	1.9367	1.376	98
Oxygen	O_2	32.00	0.0827	1.4076	1.105	246
Pentane	C_5H_{12}	72.15	0.1865	3.1738	2.491	368
Propane	C_3H_8	44.10	0.1140	1.9397	1.523	206
Propylene	C_3H_6	42.08	0.1088	1.8510	1.453	198
Sulphur Dioxide	SO_2	64.06	0.1656	2.8191	2.213	316

① Density is given for gas at 14.7 psia @ +70° F.

② Density is given for gas at 1 bar @ +0° C.

Properties: Density and Specific Gravity of Saturated Water

Temperature		Pressure	Density	S.G.	Dielectric Constant Of Liquid	Dielectric Constant Of Vapor	Error in Distance, %
°F	°C	PSI	lbs/ft³				
32	0	0.09	62.42	1.00	—	—	—
35	2	0.10	62.42	1.00	—	—	—
40	4	0.12	62.42	1.00	—	—	—
45	7	0.15	62.42	1.00	—	—	—
50	10	0.18	62.42	1.00	—	—	—
52	11	0.19	62.38	1.00	—	—	—
54	12	0.21	62.38	1.00	—	—	—
56	13	0.22	62.38	1.00	—	—	—
58	14	0.24	62.38	1.00	—	—	—
60	16	0.26	62.34	1.00	—	—	—
62	17	0.28	62.34	1.00	—	—	—
64	18	0.30	62.34	1.00	—	—	—
66	19	0.32	62.34	1.00	—	—	—
68	20	0.34	62.31	1.00	—	—	—
70	21	0.36	62.31	1.00	—	—	—
72	22	0.39	62.27	1.00	—	—	—
74	23	0.42	62.27	1.00	—	—	—
76	24	0.45	62.27	1.00	—	—	—
78	26	0.48	62.23	1.00	—	—	—
80	27	0.51	62.23	1.00	—	—	—
82	28	0.54	62.19	1.00	—	—	—
84	29	0.58	62.19	1.00	—	—	—
86	30	0.62	62.15	1.00	—	—	—
88	31	0.66	62.15	1.00	—	—	—
90	32	0.70	62.11	1.00	—	—	—
92	33	0.74	62.07	0.99	—	—	—
94	34	0.79	62.07	0.99	—	—	—
96	36	0.84	62.03	0.99	—	—	—
98	37	0.89	62.03	0.99	—	—	—
100	38	0.95	62.00	0.99	73.95	1.001	0.0
110	43	1.28	61.84	0.99	72.09	1.001	0.0
120	49	1.70	61.69	0.99	70.27	1.001	0.0
130	54	2.23	61.54	0.99	68.50	1.001	0.0
140	61	2.89	61.39	0.98	66.77	1.001	0.0
150	66	3.72	61.20	0.98	65.09	1.002	0.1
160	71	4.74	60.98	0.98	63.44	1.002	0.1
170	77	6.00	60.79	0.97	61.84	1.003	0.1
180	82	7.52	60.57	0.97	60.28	1.003	0.1
190	88	9.34	60.35	0.97	58.75	1.004	0.2
200	92	11.53	60.13	0.96	57.26	1.005	0.2

Temperature		Pressure	Density	S.G.	Dielectric Constant Of Liquid	Dielectric Constant Of Vapor	Error in Distance, %
°F	°C	PSI	lbs/ft³				
210	99	14.13	59.88	0.96	55.81	1.006	0.3
212	100	14.70	59.81	0.96	—	—	—
220	104	17.19	59.63	0.96	54.40	1.007	0.3
230	110	20.78	59.35	0.95	53.02	1.008	0.4
240	116	24.97	59.10	0.95	51.67	1.009	0.4
250	121	29.82	58.82	0.94	50.36	1.011	0.5
260	127	35.42	58.55	0.94	49.08	1.013	0.6
270	132	41.83	58.24	0.93	47.83	1.015	0.7
280	138	49.18	57.94	0.93	46.61	1.017	0.8
290	143	57.53	57.64	0.92	45.42	1.019	0.9
300	149	66.98	57.31	0.92	44.26	1.022	1.1
310	154	77.64	56.98	0.91	43.13	1.025	1.2
320	160	89.60	56.66	0.91	42.02	1.028	1.4
330	166	103.00	56.34	0.90	40.94	1.032	1.6
340	171	117.93	55.96	0.90	39.88	1.036	1.8
350	177	134.53	55.59	0.89	38.84	1.040	2.0
360	182	152.92	55.22	0.88	37.83	1.045	2.2
370	188	173.23	54.85	0.88	36.84	1.050	2.5
380	193	195.60	54.47	0.87	35.88	1.056	2.8
390	199	220.20	54.05	0.87	34.93	1.062	3.1
400	204	247.10	53.65	0.86	34.00	1.069	3.4
410	210	276.50	53.25	0.85	33.09	1.076	3.7
420	216	308.50	52.80	0.85	32.20	1.085	4.2
430	221	343.30	52.38	0.84	31.32	1.093	4.5
440	227	381.20	51.92	0.83	30.46	1.103	5.0
450	232	422.10	51.47	0.82	29.62	1.113	5.5
460	238	466.30	50.99	0.82	28.78	1.124	6.0
470	243	514.10	50.51	0.81	27.97	1.137	6.6
480	249	565.50	50.00	0.80	27.16	1.150	7.2
490	254	620.70	49.48	0.79	26.36	1.164	7.9
500	260	680.00	48.95	0.78	25.58	1.180	8.6
520	271	811.40	47.82	0.77	24.04	1.216	10.3
540	282	961.50	46.62	0.75	22.52	1.260	12.2
560	293	1131.80	45.31	0.73	21.03	1.313	14.6
580	304	1324.30	43.90	0.70	19.54	1.378	17.4
600	316	1541.00	42.32	0.68	18.04	1.461	20.9
620	327	1784.40	40.57	0.65	16.52	1.570	25.3
640	338	2057.10	38.57	0.62	14.93	1.719	31.1
660	349	2362.00	36.14	0.58	13.23	1.938	39.2
680	360	2705.00	32.98	0.53	11.23	2.310	52.0
700	371	3090.00	27.28	0.44	8.29	3.295	81.5
705	374	3204.00	19.79	0.32	—	—	—

Properties: Density of Superheated Steam and Compressed Water

Temperature		Superheated Steam and Compressed Water Density lbm/ft³										
°F	°C	1 PSIA	2 PSIA	5 PSIA	10 PSIA	20 PSIA	50 PSIA	100 PSIA	200 PSIA	500 PSIA	750 PSIA	1000 PSIA
32	0	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.46	62.54	62.58	62.62
40	4	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.46	62.54	62.58	62.62
60	16	62.37	62.37	62.37	62.37	62.37	62.37	62.37	62.42	62.46	62.50	62.58
80	27	62.23	62.23	62.23	62.23	62.23	62.23	62.23	62.27	62.31	62.38	62.42
100	38	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.04	62.07	62.15	62.19
120	49	.002901	61.73	61.73	61.73	61.73	61.73	61.73	61.77	61.81	61.84	61.88
140	60	.002804	.005619	61.39	61.39	61.39	61.39	61.39	61.43	61.46	61.50	61.58
160	71	.002713	.005435	60.98	60.98	61.01	61.01	61.01	61.01	61.09	61.13	61.20
180	82	.002628	.005263	.01321	60.55	60.57	60.57	60.57	60.61	60.68	60.72	60.75
200	93	.002548	.005101	.01280	.02575	60.10	60.13	60.13	60.13	60.21	60.24	60.31
220	104	.002472	.004950	.01241	.02495	59.59	59.60	59.60	59.67	59.70	59.77	59.81
240	116	.002402	.004807	.01205	.02420	.04885	59.10	59.10	59.10	59.17	59.24	59.28
260	127	.002334	.004672	.01171	.02351	.04738	58.51	58.55	58.55	58.62	58.69	58.72
280	138	.002271	.004545	.01139	.02285	.04602	57.94	57.94	57.97	58.04	58.07	58.14
300	149	.002211	.004425	.01108	.02223	.04473	.1140	57.31	57.34	57.41	57.57	57.54
320	160	.002154	.004311	.01079	.02165	.04352	.1107	56.63	56.66	56.75	56.82	56.88
340	171	.002100	.004203	.01052	.02109	.04239	.1076	.2213	55.96	56.05	56.12	56.18
360	182	.002049	.004100	.01026	.02057	.04131	.1047	.2146	55.22	55.31	55.40	55.46
380	193	.002000	.004002	.01002	.02007	.04029	.1019	.2084	54.47	54.56	54.65	54.71
400	204	.001954	.003908	.009781	.01960	.03933	.09938	.2026	.4238	53.74	53.82	53.91
420	216	.001909	.003819	.009557	.01914	.03841	.09696	.1973	.4104	52.88	52.97	53.08
440	227	.001866	.003734	.009343	.01871	.03753	09466	.1923	.3982	51.98	52.08	52.17
460	238	.001826	.003653	.009139	.01830	.03670	.09249	.1876	.3870	50.99	51.13	51.23
480	249	.001787	.003575	.008944	.01791	.03590	.09042	.1832	.3766	1.049	50.08	50.20
500	260	.001750	.003500	.008756	.01753	.03514	.08845	.1790	.3670	1.008	48.97	49.12
520	271	.001714	.003429	.008576	.01717	03441	.08657	.1750	.3580	.9728	1.603	47.94
540	282	.001680	.003360	.008405	.01682	.03371	.08477	.1712	.3496	.9413	1.530	46.64
560	293	.001647	.003294	.008239	.01649	.03304	.08305	.1676	.3416	.9128	1.468	2.142
580	304	.001615	.003230	.008080	.01617	.03240	.08140	.1642	.3341	.8870	1.415	2.035
600	316	.001585	.003169	.007927	.01587	.03178	.07982	.1609	.3270	.8633	1.367	1.947
620	327	.001555	.003111	.007780	.01557	.03119	.07830	.1577	.3202	.8413	1.325	1.871
640	338	.001527	.003054	.007638	.01529	.03061	.07683	.1547	.3137	.8209	1.287	1.804
660	349	.001499	.002999	.007501	.01501	.03006	.07543	.1518	.3076	.8019	1.252	1.746
680	360	.001473	.002947	.007369	.01475	.02953	.07408	.1490	.3017	.7840	1.219	1.693
700	371	.001448	.002896	.007242	.01449	.02902	.07278	.1464	.2960	.7671	1.189	1.645
720	382	.001423	.002847	.007119	.01425	.02852	.07152	.1438	.2906	.7510	1.161	1.601
740	393	.001400	.002799	.007000	.01401	.02804	.07030	.1413	.2854	.7359	1.135	1.560
760	404	.001376	.002753	.006885	.01378	.02758	.06913	.1389	.2804	.7215	1.111	1.523
780	416	.001354	.002709	.006774	.01355	.02713	.06800	.1366	.2755	.7077	1.087	1.488
800	427	.001333	.002666	.006666	.01334	.02670	.06690	.1344	.2709	.6946	1.065	1.455
820	438	.001312	.002624	.006562	.01313	.02628	.06584	.1322	.2664	.6820	1.045	1.424
840	449	.001292	002584	.006461	.01293	.02587	.06482	.1301	.2621	.6700	1.025	1.394
860	460	.001272	.002545	.006363	.01273	.02548	.06382	.1281	.2579	.6584	1.006	1.367
880	471	.001253	.002507	.006268	.01254	.02509	.06286	.1261	.2539	.6473	.9877	1.340
900	482	.001235	.002470	.006175	.01235	.02472	.06192	.1242	.2500	.6366	.9703	1.315
920	493	.001217	.002434	.006086	.01217	.02436	.06101	.1224	.2462	.6263	.9537	1.291
940	504	.001199	.002399	.005998	.01200	.02401	.06013	.1206	.2425	.6163	.9377	1.269
960	516	.001182	.002365	.005914	.01183	.02367	.05928	.1187	.2389	.6068	.9223	1.247
980	527	.001166	.002332	.005832	.01167	.02334	.05845	.1172	.2355	.5976	.9075	1.226
1000	538	.001150	.002300	.005752	.01151	.02302	.05764	.1155	.2321	.5885	.8933	1.206
Saturated Steam		.002998	.005755	.01360	.02603	.04978	.1175	.2257	.4372	1.078	1.641	2.242
Saturated Water		61.96	61.61	60.94	60.28	59.42	57.90	56.37	54.38	50.63	48.33	46.32
Tsat °F		101.74	126.07	162.24	193.21	227.96	281.02	327.82	381.80	467.01	510.84	544.58

Properties: Specific Gravity of Petroleum Products

Temperature Relationship for Petroleum Oils

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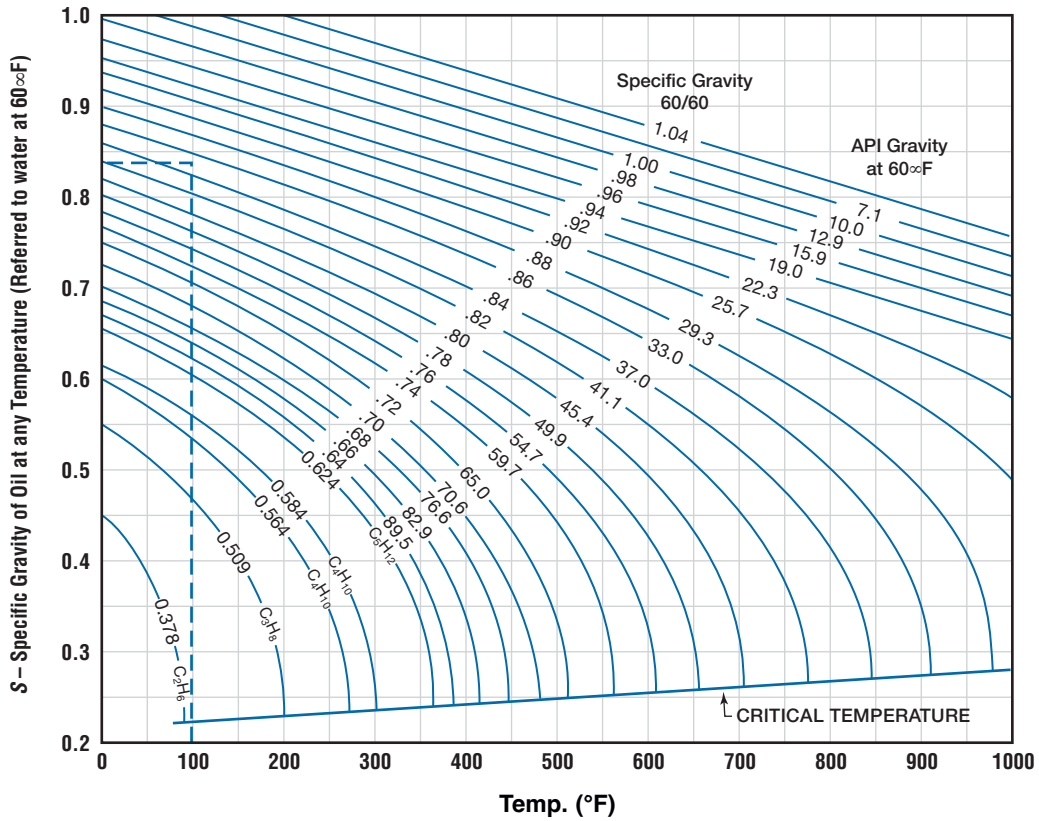


C_2H_6 = Ethane
C_3H_8 = Propane
C_4H_{10} = Butane
iC_4H_{10} = Isobutane
iC_5H_{12} = Isopentane

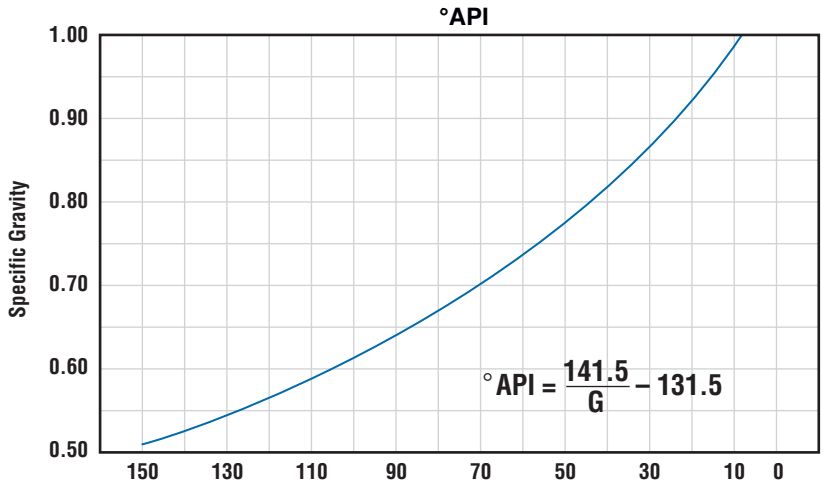
Example: The specific gravity of an oil at 60°F is 0.85. The specific gravity at 100°F = 0.83.

To find the weight density of a petroleum oil at its flowing temperature when the specific gravity at 60°F is known, multiply the specific gravity of the oil at flowing temperature (see chart above) by 62.4, the density of water at 60°F.

*Reprinted from Crane Company's Technical Paper 410.

Specific Gravity versus API Gravity

(for hydrocarbon based products and water gravity °A.P.I.)



Properties: Density of Air

Temperature		Air Density lbm/ft³											
°F	°C	14.73 PSIA	100 PSIA	200 PSIA	300 PSIA	400 PSIA	500 PSIA	600 PSIA	700 PSIA	800 PSIA	900 PSIA	1000 PSIA	1100 PSIA
–40	–40	0.0949	0.6488	1.3087	1.9796	2.661	3.3525	4.0533	4.7628	5.4768	6.2031	6.9315	7.6632
–20	–29	0.0905	0.6182	1.245	1.8799	2.5227	3.1728	3.8295	4.492	5.1594	5.8308	6.5051	7.1811
0	–18	0.0866	0.5905	1.1875	1.7906	2.3995	3.0135	3.6321	4.2547	4.8805	5.5086	6.1382	6.7684
20	– 7	0.0830	0.5652	1.1353	1.71	2.2887	2.8711	3.4567	4.0447	4.6347	5.2258	5.8175	6.409
40	4	0.0797	0.5421	1.0878	1.6368	2.1886	2.7429	3.2992	3.857	4.4157	4.9748	5.5338	6.092
60	16	0.0765	0.5208	1.0442	1.5699	2.0974	2.6266	3.1569	3.6879	4.2191	4.7502	5.2805	5.8098
80	27	0.0737	0.5012	1.0041	1.5085	2.0141	2.5205	3.0275	3.5347	4.0416	4.5478	5.0529	5.5567
100	38	0.0711	0.4829	0.9670	1.4519	1.9375	2.4234	2.9093	3.3949	3.8798	4.3637	4.8464	5.3274
120	49	0.0687	0.4660	0.9327	1.3997	1.8668	2.3339	2.8006	3.2666	3.7316	4.1954	4.6577	5.1184
140	60	0.0664	0.4503	0.9007	1.3511	1.8013	2.2511	2.7001	3.1482	3.5951	4.0406	4.4845	4.9265
160	71	0.0641	0.4356	0.871	1.3061	1.7406	2.1744	2.6073	3.0391	3.4695	3.8985	4.3257	4.7509
180	82	0.0621	0.4218	0.8432	1.264	1.684	2.103	2.521	2.938	3.3529	3.7665	4.1783	4.5882
200	93	0.0602	0.4089	0.8171	1.2246	1.6311	2.0364	2.4405	2.8432	3.2444	3.6439	4.0417	4.4375
220	104	0.0585	0.3967	0.7927	1.1877	1.5815	1.9741	2.3654	2.7551	3.1432	3.5296	3.9144	4.2972
240	116	0.0568	0.3853	0.7697	1.1529	1.5349	1.9156	2.2948	2.6725	3.0485	3.4228	3.7953	4.1658
260	127	0.0552	0.3745	0.7480	1.1202	1.4911	1.8606	2.2288	2.5956	2.9608	3.3239	3.6846	4.0424
280	138	0.0537	0.3644	0.7275	1.0893	1.4497	1.8088	2.1666	2.5231	2.8779	3.2306	3.4803	3.9264
300	149	0.0523	0.3547	0.7081	1.0601	1.4107	1.7599	2.1078	2.4546	2.7997	3.1424	3.4819	3.8174
320	160	0.0510	0.3456	0.6898	1.0325	1.3737	1.7136	1.9997	2.3897	2.7256	3.059	3.389	3.7147
340	171	0.0497	0.3369	0.6724	1.0063	1.3388	1.6698	2.0523	2.6553	2.6553	2.98	3.3013	3.6184

Properties: Speed of Sound

Gases	m/sec	ft/sec
air, dry	331	1086
ammonia	415	1362
argon	308	1010
carbon dioxide	259	850
carbon monoxide	338	1109
chlorine	206	676
deuterium	890	2920
ethane	308	1010
ethylene	317	1040
helium	965	3166
hydrogen	1284	4213
hydrogen bromide	200	656
hydrogen chloride	206	676
hydrogen iodide	157	515
hydrogen sulfide	289	948
illuminating (coal gas)	453	1486
methane	430	1411
neon	435	1427
nitric oxide	324	1063
nitrogen	334	1096
nitrous oxide	263	863
oxygen	316	1037
sulfur dioxide	213	699

Vapors	m/sec	ft/sec
acetone	230	755
benzene	202	663
carbon tetrachloride	145	476
chloroform	171	561
ethanol	269	883
ethyl ether	206	676
methanol	335	1099
water	494	1621

Note: the speed of sound in gases is measured at 32°F (0°C) except ethane and nitric oxide which is measured at 50°F (10°C). The speed of sound in vapors is measured at 206°F (97°C) except water which is measured at 270°F (134°C).

Properties: Dielectric Constants of Liquids

This listing contains dielectric values for the most commonly used materials. This information can be used to help select a probe, establish how much capacitance information your particular application will develop, or determine the effect of a coating on the probe.

Non-conductive materials are those with dielectric values less than 10. Conductive materials are those with dielectric values greater than 10.

Liquids	Temperature		Dielectric Constant
	°F	°C	
Acenaphthene	70	21	3.0
Acetal	70	21	3.6
Acetaldehyde	50	10	22.2
Acetaldoxime	70	21	3.4
Acetamide	68	20	4.0
Acetanilide	71	22	2.9
Acetic Acid	65	18	6.1
Acetic Anhydride	70	21	22.0
Acetone	75	24	20.7
Acetone	80	27	20.7
Acetone	130	54	17.7
Acetonitrile	70	21	37.5
Acetophenone	75	24	17.3
Acetoxime	75	24	3.0
Acetylacetone	68	20	23.1
Acetylbromide	68	20	16.5
Acetylchloride	68	20	15.8
Acetylmethyl Hexyl Ketone	66	19	27.9
Acrylic Resin	70	20	3.0
Aliphatic Amine	195	90	7.2
Allyl Alcohol	70	21	21.0
Allyl Bromide	66	19	7.0
Allyl Chloride	68	20	8.2
Allyl Iodide	66	19	6.1
Allyl Isothiocyanate	64	18	17.5
Alluminum Bromide	212	100	3.4
Alluminum Oleate	68	20	2.4
Alox 600	130	54	4.1
Aminox	275	135	2.4
Ammonia	-30	-34	22.4
Ammonia	-104	-75	25.0
Ammonia	75	24	16.9
Ammonia, Aqueous	70	21	16.8
Amyl Acetate	68	20	5.0
Amyl Alcohol	-180	-118	35.5
Amyl Alcohol	68	20	15.8
Amyl Alcohol	140	60	11.2
Amylamine	72	22	4.6
Amyl Benzoate	68	20	5.1
Amyl Bromide	50	10	6.3
Amyl Chloride	52	11	6.6
Amylene	70	21	2.0
Amylene Bromide	58	14	5.6
Amyl Ether	60	16	3.1
Amyl Formate	66	19	5.7
Amyl Iodide	62	17	6.9
Amylmercapton	68	20	4.7
Amyl Nitrate	62	17	9.1
Amyl Thiocyanate	68	20	17.4
Aniline	32	0	7.8
Aniline	68	20	7.3
Aniline	212	100	5.5
Anisaldehyde	68	20	15.8
Anisoldoxine	145	63	9.2
Anisole	68	20	4.3
Antimony Pentachloride	68	20	3.2
Antimony Tribromide	212	100	20.9
Antimony Trichloride	166	74	33.0
Antimony Tricodide	347	175	13.9
Arsenic Tribromide	98	37	9.0

Liquids	Temperature		Dielectric Constant
	°F	°C	
Arsenic Trichloride	70	21	12.4
Arsenic Triiodide	302	150	7.0
Arsine	-58	-50	2.7
Asphalt	75	24	2.7
Azoxyanisole	122	50	2.3
Azoxybenzene	104	40	5.1
BPA	68	20	5.0
Beef Talo	70	21	2.8
Benzal Chloride	68	20	6.9
Benzaldehyde	68	20	17.0
Benzaldoxime	68	20	3.8
Benzene	68	20	2.3
Benzil	202	95	13.0
Benzonitrile	68	20	26.0
Benzonitrile	160	71	22.0
Benzophenone	68	20	13.0
Benzophenone	122	50	11.4
Benzotrichloride	68	20	7.4
Benzoylacetone	68	20	3.8
Benzoyl Chloride	158	70	22.1
Benzoyl Chloride	75	24	19.0
Benzyl Acetate	70	21	5.0
Benzyl Alcohol	68	20	13.0
Benzylamine	68	20	4.6
Benzyl Benzoate	68	20	4.8
Benzyl Chloride	68	20	6.4
Benzyl Cyanide	68	20	18.3
Benzyl Ethylamine	68	20	4.3
Benzyl Methylamine	67	19	4.4
Benzyl Salicylate	68	20	4.1
Bornyl Acetate	70	21	4.6
Boron Bromide	32	0	2.6
Boronyl Chloride	202	95	5.2
Bromal	70	21	7.6
Bromocotyl Bromide	68	20	12.6
Bromohexadecane	76	24	3.7
Bromine	68	20	3.1
Bromo-2-Ethoxyheptane	68	20	5.5
Bromoaniline	66	19	13.0
Bromoanisole	86	30	7.1
Bromobenzene	68	20	5.4
Bromobutylene	68	20	5.8
Bromobutyric Acid	68	20	7.2
Bromodecane	76	24	4.4
Bromodocosane	130	54	3.1
Bromododocane	76	24	4.1
Bromo-2-Othoxypentane	76	24	6.5
Bromoform	68	20	4.4
Bromoheptane	76	24	5.3
Bromohexane	76	24	5.8
Bromolsovoleric Acid	68	20	6.5
Bromonaphtholene	66	19	5.1
Bromooctodecane	86	30	3.5
Bromopentaeocane	68	20	3.9
Bromoproplonic Acid	68	20	11.0
Bromotoluene	68	20	5.1
Bromotridecone	50	10	4.2
Bromoundecone	15	–9	4.7
Butadiene	77	25	2.4
Butane	30	–1	1.4
N-Butylacetate	66	19	5.1

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Iso-Butylacetate	68	20	5.6
Iso-Butylamine	70	21	4.5
N-Butyl Alcohol	66	19	7.8
Iso-Butyl Alcohol	112	45	31.7
Iso-Butyl Alochol	32	0	20.5
Iso-Butyl Alcohol	68	20	18.7
Butylomine	70	21	5.4
N-Butyl Bromide	68	20	6.6
Butyl Chlorol	64	18	10.0
Butyl Chloride	68	20	9.6
N-Butyl Formate	317	158	2.4
N-Butyl Iodide	77	25	6.1
Iso-Butyl Iodide	68	20	5.8
Iso-Butyl Nitrate	66	19	11.9
Butyric Anhydride	68	20	12.0
Butyroldehyda	79	26	13.4
Butyric Acid	68	20	2.8
N-Butyricacid	68	20	2.9
Iso-Butyric Acid	68	20	2.7
Butyric Anhydride	68	20	12.9
Butyronitrile	70	21	20.7
Iso-Butyronitrile	75	24	20.8
Cable Oil	75	24	2.2
Camphanedione	398	203	16.0
Camphene	68	20	2.7
Camphorpinacane	68	20	3.6
Caproic Acid	160	71	2.6
Caprolactum	180	82	13.1
Caprylic Acid	65	18	3.2
Carbon Dioxide	32	0	1.6
Carbon Dioxide	-110	-80	2.1
Carbon Disulfide	68	20	2.6
Carbon Tetrachloride	68	20	2.2
Carvenone	68	20	18.4
Carveol	64	18	11.2
Carvone	71	22	11.0
Castor Oil	58	14	4.8
Castor Oil	75	24	2.6
Camphene	104	40	2.3
Camphoric Imide	480	249	5.5
Cetyl Iodide	68	20	3.3
Chloral Hydrate	59	15	5.5
Chlorocetic Acid	140	60	12.3
Chlorine	32	0	2.0
Chloroocelle Acid	68	20	21.0
Chloroacetone	68	20	29.8
Chlorobenzene	68	20	5.9
Chlorobenzene	212	100	4.7
Chlorocyclohexane	76	24	7.6
Chloroheptane	71	22	5.5
Chloroform	32	0	5.5
Chlorohexanone oxime	192	89	3.0
Chlorohydrate	68	20	3.3
Chloronophtholene	76	24	5.0
O-Chlorophenol	66	19	8.2
3-Chloro-1, Dihydroxprone	68	20	31.0
Chlorooctane	76	24	5.1
Chlorotoluene	68	20	4.7
Cholestrol	80	27	2.9
Chorine	170	77	1.7
Chromyl Chloride	68	20	2.6
Cis-3-Hexene	76	24	2.1
Cinnamaldehyde	75	24	16.9
Citranconic Anhydride	68	20	40.3
Cocaine	68	20	3.1
Copper Oleate	68	20	2.8
Creosol	62	17	10.6
O-Cresol	75	24	5.8
M-Cresol	75	24	5.0
P-Cresol	75	24	5.6

Liquids	Temperature		Dielectric Constant
	°F	°C	
Cresol	75	24	5.0
Crisco Oil	130	54	2.2
Crotonic Nitrice	68	20	28.0
Cumaldehyde	59	15	11.0
Cumene	68	20	2.4
Cumicaldehyde	58	14	10.7
Cupric Oxide	60	16	18.1
Cyanoacetic Acid	40	4	33.0
Cyanoethyl Acetate	68	20	19.3
Cyanogen	73	23	2.6
Cyclohedane	68	20	2.0
Cyclohexane	68	20	2.0
Cyclohexanecarboxylic Acid	88	31	2.6
Cyclohexanone oxime	192	89	3.0
Cyclohexanemethanol	140	60	9.7
Cyclohexanone	68	20	18.2
Cyclohexylomine	–5	–21	5.3
Cyclohexylphenol	130	54	4.0
Cyclohexyltrifluoromethane	-120	-84	11.0
Cyclohexanol	77	25	15.0
Cyclopentane	68	20	2.2
P-Cymene	63	17	2.3
Cymene	62	17	2.3
Decahydronaphthalene	68	20	2.2
Decamethylcyclopentasiloxane	68	20	2.5
Decamethyltetrasiloxane	68	20	2.4
Decane	68	20	2.0
Decane	340	171	1.8
Decylene	62	17	2.7
Decyne	68	20	2.2
Decanol	68	20	8.1
Deuterium	68	20	1.3
Deuterium Oxide	76	24	78.3
Diacetoxybutane	76	24	6.6
Diallyl Sufide	68	20	4.9
Dibenzyl Sebacate	68	20	4.6
Dibroheptane	24	-4	5.1
Dibromobenzene	68	20	8.8
P-Dibromobenzene	190	88	4.5
Dibromobutane	68	20	5.7
Dibromoethylene	32	0	7.7
Dibromomethane	50	10	7.8
Dibromoheptane	76	24	5.1
Dibromohexane	76	24	5.0
Dibromopropane	68	20	4.3
Dibromopropyl Alcohol	70	21	9.1
Dibenzylomine	68	20	3.6
Dibutyl phtolote	86	30	6.4
Dibutyl tartrote	109	43	9.4
Dichlorocetic Acid	68	20	10.7
Dibutyl sebacote	86	30	4.5
Dichlorocotone	68	20	14.0
O-Dichlorobenzone	77	25	7.5
P-Dichlorobenzone	68	20	2.9
O-Dichlorobenzene	68	20	7.5
Dichlorobenzene	127	53	2.8
1, 2-Dichloroethane	77	25	10.7
Dichloroethane	68	20	16.7
Dichlorostyrene	76	24	2.6
Dichlorotoluene	68	20	6.9
Dicyclohexyladipate	95	35	4.8
Diesel	70	21	1.9
1-Diethoxyethane	76	24	3.8
Diethyloniline	66	19	5.5
Diethyl Benzalmalamate	32	0	8.0
Diethyl Di-malmate	64	18	10.2
Diethyl Disulfide	64	18	15.9
Diethyl Glutarate	86	30	6.7
Diethyl Ketone	58	14	17.3
Diethyl-L-malate	68	20	9.5

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Diethyl Malanate	70	21	7.9
Diethylamine	68	20	3.7
Diethyl Oxalate	70	21	8.2
Diethyl Oxalacetate	66	19	6.1
Diethyl Racemote	68	20	4.5
Diethyl Sebacate	86	30	5.0
Diethyl Succinate	86	30	6.6
Diethyl Succinosuccinate	66	19	2.5
Diethyl Sulfide	68	20	7.2
Diethyl Sulfite	68	20	15.9
Diethyl Tortrate	68	20	4.5
Diethyl Disulfide	66	19	15.9
Dihydrocoroane	66	19	8.7
Dihydrocorvane	66	19	8.5
Diimylamine	64	18	2.5
Diioomylene	62	17	2.4
Diiodoethylene	180	82	4.0
Diiodomethane	76	24	5.3
Diisoomyl	62	17	2.0
Diisobutylomine	71	22	2.7
Dimethoxybenzene	73	23	4.5
Dimethylbromoethylene	68	20	6.7
Dimethyldichloro Silane	68	20	12.3
Dimethyleyclohexyomine	180	82	4.4
Dimethyloniline	68	20	4.4
Dimethyl Ethyl	68	20	11.7
Dimethyl Ethyl Carbinol	68	20	11.7
Dimethylheptane	68	20	1.9
Dimethyl-2-hexane	68	20	2.4
Dimethyl-1-Hydroxybenzene	62	17	4.8
Dimethyl Malanate	68	20	10.4
Dimethyl Oxalate	68	20	3.0
Dimethylpentane	68	20	1.9
Dimethylquinoxaline	76	24	2.3
Dimethyl Sulfide	68	20	6.3
Dimethyl Sulfate	68	20	55.0
D imethyltoluidine	68	20	3.3
M-Dinitro Benzene	68	20	2.8
Dinitrogen Oxide	32	0	1.6
Dinitrogen Tetroxide	58	14	2.5
Dioctyl phthalate	76	24	5.1
Dioxane 1,4	77	25	2.2
Dipolmitin	161	72	3.5
Dipentene	68	20.	2.3
Diphenyl	166	74	2.5
Diphenylomine	125	52	3.3
Diphenylethane	230	110	2.4
Diphenyl Ether	82	28	3.9
Diphenylmethane	62	17	2.6
Diproppylomine	70	21	2.9
Dipropyl Ketone	62	17	12.6
Distearin	172	78	3.3
Docosane	122	50	2.0
Dodeanol	76	24	6.5
Dodecamethylcyclohexisolox	68	20	2.6
Dodecamethylpentasiloxane	68	20	2.5
Dodecyne	76	24	2.2
Dowtherm	70	21	3.4
Epichlorohydrin	68	20	22.9
Epon Resin	75	24	13.3
Ethonediomine	68	20	14.2
Ethanethiol	58	14	6.9
Ethanethiolic Acid	68	20	13.0
Ethanol	77	25	24.3
Ethenolamine	68	20	37.0
Ether	75	25	4.3
Ethoxybenzene	68	20	4.2
Ethoxyethyl Acetate	86	30	7.6
Ethoxypentane	73	23	3.6
Ethoxy-3-metylbutane	68	20	4.0

Liquids	Temperature		Dielectric Constant
	°F	°C	
Ethoxytoluene	68	20	3.9
Ethoxynaphthalene	66	19	3.3
Ethyl Acetate	68	20	6.4
Ethyl Acetoacetate	71	22	15.9
Ethyl Acetoneoxalate	66	19	16.1
Ethyl Acetophenoneoxalate	66	19	3.3
Ethyl Alcohol	77	25	24.3
Ethyl Acrylate	257	125	11.7
Ethylamine	70	21	6.3
Ethyl Amyl Ether	68	20	4.0
Ethyloniline	68	20	5.9
Ethyl Benzene	68	0	5.5
Ethyl Benzoate	68	20	6.0
Ethyl Benzoylacetate	68	20	12.8
Ethyl Benzoylacetoacetate	70	21	8.6
Ethyl Benzyl Ether	68	20	3.8
Ethyl 1-Brombutyrate	68	20	8.0
Ethyl Bromide	64	18	4.9
Ethyl Bromoisobutyrate	68	20	7.9
Ethyl Bromoproprionate	68	20	9.4
Ethyl Butyrate	68	20	5.1
Ethyl Carbonate	68	20	3.1
Ethyl Chloracetate	68	20	11.6
Ethyl Chloroformate	68	20	11.3
Ethyl Chloropropionate	68	20	10.1
Ethyl Cinnamate	66	19	5.3
Ethyl Cyanoacetate	68	20	27.0
Ethyl Cyclobutane	68	20	2.0
Ethyl Dodeconoate	68	20	3.4
Ethylene	68	20	1.6
Ethylene Chloride	68	20	10.5
Ethylene Chlorohydrin	75	24	25.0
Ethylene Cyanide	136	58	58.3
Ethylenediamine	64	18	16.0
Ethylene Glycol	68	20	37.0
Ethylene Oxide	30	–1	13.9
Ethyl Ether	–148	–100	8.1
Ethyl Ether	–40	–40	5.7
Ethyl Ether	68	20	4.3
Ethyl Ethoxybenzoate	70	21	7.1
Ethyl Formate	66	19	8.4
Ethyl Formylphenylacetate	68	20	3.0
Ethyl Fumorate	73	23	6.5
Ethyl Iodide	68	20	7.4
Ethyl 2-Iodoproprionate	68	20	8.8
Ethyl Iso-Thioconate	68	20	19.7
Ethyl Isothiocyanate	68	20	19.7
Ethyl Levulinate	70	21	12.1
Ethyl Maleate	73	23	8.5
Ethyl Mercoptan	68	20	8.0
Ethyl Nitrate	68	20	19.7
Ethyl Oleate	80	27	3.2
Ethyl Polmitate	68	20	3.2
Ethyl Pentane	68	20	1.9
Ethyl Phenylacetate	70	21	5.4
Ethyl Propionate	68	20	5.7
Ethyl Solicylate	70	21	8.6
Ethyl Silicate	68	20	4.1
Ethyl Stearate	104	40	3.0
Ethyl Toluene	76	24	2.2
Ethyl Trichloroacetate	68	20	7.8
Ethyl Thiocyanate	68	20	29.6
Ethyl Undeconoate	68	20	3.6
Ethyl Volerate	68	20	4.7
Ethyl Benzene	76	24	3.0
Etibine	–58	–50	2.5
Eugenol	64	18	6.1
Fenchone	68	20	12.0
Ferric Oleate	68	20	2.6
Ferrous Oxide	60	16	14.2

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Ferrous Sulfate	58	14	14.2
Flexol	75	24	5.3
Flourine	-332	-20	1.5
Fluorotoluene	86	30	4.2
Formamide	68	20	84.0
Formic Acid	60	16	58.5
Freon 12	70	21	2.4
Freon 11	70	21	3.1
Freon 113	70	21	2.6
Furan	76	24	2.9
Furfuraldehyde	68	20	41.9
Furmanium Tetrachloride	76	24	2.4
Furfural	70	21	42.0
Gasoline	70	21	2.0
Germanium Tetrachloride	77	25	2.4
Grapeseed Oil	60	16	2.9
Glycerine	68	20	47.0
Glycerol	68	20	43.0
Glycerol	32	0	47.2
Glycerol Triacetate	70	21	6.0
Glycol	68	20	42.2
Glycol	122	50	35.6
Glycolic Nitrile	68	20	27.0
Guaiacol	0	–18	11.0
Glucohepititol	248	120	27.0
Hagemannic Ester	68	20	10.6
Helium-3	58	14	1.1
Heptadecconome	140	60	5.3
Heptane	68	20	1.9
Heptanone	68	20	11.9
Heptanoic Acid	160	71	2.6
Heptyl Alcohol	70	21	6.7
Hexamethylene	75	24	14.1
Hexamethylene Diamine	150	66	6.0
Hexomethyldisiloxane	68	20	2.2
Hexane	68	20	1.9
Hexanol	76	24	13.3
Hexanone	59	15	14.6
Hexdecamethylcyloheptasiloxane	68	20	2.7
Hexyl Iodide	68	20	6.6
Hexylene	62	17	2.0
Hydrocyanic Acid	70	21	2.3
Hydrofluoric Acid	32	0	83.6
Hydrogen	-423	-253	1.2
Hydrogen Bromide	76	24	3.8
Hydrogen Chloride	82	28	4.6
Hydrogen Cyanide	70	21	95.4
Hydrogen Fluoride	32	0	84.0
Hydrogen Iodide	72	22	2.9
Hydrogen Peroxide	32	0	84.2
Hydrogen Sulfide	–120	–84	9.3
Hydrogen Sulfide	48	9	5.8
Hydroxy-4-Methyl-2-Pentanone	76	24	18.2
Hydroxymethylene Camphor	86	30	5.2
Hydroxymethylenebenzyl Cyanide	68	20	6
Hydrazine	68	20	52.9
Indanol	140	60	7.8
Ido-Iedohexodecane	68	20	3.5
Iodine	284	140	11.0
Iodohexane	68	20	5.4
Iodoheptane	71	22	4.9
Iodomethane	68	20	7.0
Iodotoluene	68	20	6.1
Isoamyl Alcohol	74	23	15.3
Iodooctane	76	24	4.6
Isoamyl Bromide	76	24	6.1
Isoamyl Butyrate	68	20	3.9
Isoamyl Chlorocetate	68	20	7.8
Isoamyl Chloride	64	18	6.4
Isoamyl Chloroformate	68	20	7.8

Liquids	Temperature		Dielectric Constant
	°F	°C	
Isoamyl Iodide	65	18	5.6
Isoamyl Propionate	68	20	4.2
Isoamyl Solicylate	68	20	5.4
Isoamyl Volerate	66	20	3.6
Isobutyl Acetate	68	20	5.6
Isobutyl Alcohol	68	20	18.7
Isobutylamine	70	21	4.5
Isobutyl Benzene	62	17	2.3
Isobutyl Benzoate	68	20	5.9
Isobutyl Bromide	68	20	6.6
Isobutyl Bulyrate	68	20	4.0
Isobutyl Chloride	68	20	7.1
Isobutyl Cyanide	74	23	13.3
Isobutyl Chloroformate	68	20	9.2
Isobutyl Formate	66	18	6.5
Isobutylene Bromide	68	20	4.0
Isobutyl Iodide	68	20	5.8
Isobutyl Nitrate	66	19	11.9
Isobutyl Rininoleate	70	21	4.7
Isobutyl Volerate	66	19	3.8
Isobutryic Acid	68	20	2.6
Isobutryic Anhydride	68	20	13.9
Isobutyronitrila	75	24	20.8
Isocopronitrilo	68	20	15.7
Isopropyl Alcohol (IPA)	68	20	18.3
Isopropylamine	68	20	5.5
Isopropyl Benzene	68	20	2.4
Isopropylether	77	25	3.9
Isopropyl Nitrate	66	19	11.5
Isoquinoline	76	24	10.7
Isonofrol	70	21	3.4
IsoValeric Acid	68	20	2.7
Jet Fuel (Military—JP4)	70	21	1.7
Kerosene	70	21	1.8
Lactic Acid	66	19	19.4
Lactonitrilla	68	20	38.4
Lead Carbonate	60	16	18.1
Lead Nomoxide	60	16	25.9
Lead Oleate	64	18	3.2
Lead Tetrachloride	68	20	2.8
Lecithin	120	49	3.5
Lemon Oil	70	21	2.3
Limonene	68	20	2.3
Linseed Oil	55	13	3.4
Linoleic Acid	32	0	2.9
Lonone	65	18	10.0
Malonic Nitrate	97	36	47.0
Maleic Anhydride	140	60	51.0
Mannitol	71	22	3.0
Mandelic Nitrile	73	23	18.1
Mandenitrile	73	23	17.0
Menthol	107	42	4.0
Menthenol	110	43	2.1
Methallmine	77	25	9.4
Methoxyethyl Stearate	140	60	3.4
Mercury Diethyl	68	20	2.3
Mesitylene	68	20	2.4
Mesitylene	68	20	3.4
Mesityl Oxide	68	20	15.4
Methal Cyanacetate	69	21	29.4
Methane	32	0	1.6
Methane	-280	-173	1.7
Methanol	77	25	33.6
Methoxybenzene	76	24	4.3
Methoxytoluene	68	20	3.5
Methoxy-4-Methylphenol	60	16	11.0
Methyl Acetate	68	20	7.3
Methyl Acetopheononoaxalate	64	18	2.8
Methylal	68	20	2.7
Methyl Alcohol	–112	–80	56.6

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Methyl Alcohol	32	0	37.5
Methyl Alcohol	68	20	33.1
Methylamine	70	21	10.5
Methyl Benzoate	68	20	6.6
Methyl Benzylamine	65	18	4.4
Methyl Butane	68	20	1.8
Methyl Butyl Ketone	62	17	12.4
Methyl Butyrate	68	20	5.6
Methyl Chloracetate	68	20	12.9
Methyl Chloride	77	25	12.9
Methyl Cyclohexonal	68	20	13.0
Methyl Cyclohexanone	192	89	18.0
Methyl Cyclopentane	68	20	2.0
Methyl-1-Cyclopentanol	95	35	6.9
Methylene Chloride	70	20	9.3
Methylene Iodide	70	21	5.1
Methyl Ether	78	26	5.0
Methyl Ethyl Ketone	72	22	18.4
Methyl Ethyl Ketoxime	68	20	3.4
Methyl Heptanol	68	20	5.3
Methyl Hexane	68	20	1.9
Methyl Kezyl Ketone	62	17	10.7
Methyl Iodide	68	20	7.1
Methyl-5 Ketocyclohexylene	68	20	24.0
Methyl Nitrobenzoate	80	27	27.0
Methyl Octane	69	21	30.0
Methoxyphenol	82	28	11.0
Methyl O-Methoxybenzoate	70	21	7.8
Methyl-2, 4-Pentonddiol	86	30	24.4
Methyl-2-Pentoene	68	21	13.1
Methylphenyl Hydrazin	66	19	7.3
Methyl Propionate	66	19	5.4
Methyl Propyl Ketone	58	14	16.8
Methyl p-toluate	91	33	4.3
Methyl Salicylate	68	20	9.0
Methyl Thiocyanate	68	20	35.9
Methyl Trichloro Silane	68	20	6.8
Methyl Tertiary-butyl Ether (MTBE)	68	20	2.6
Methyl Volorate	66	19	4.3
Metilox	160	71	4.5
Mineral Oil	80	27	2.1
Misella	68	20	1.9
Monomyristin	158	70	6.1
Monopalmitin	152	67	5.3
Monostearin	170	77	4.9
Nanene	50	10	2.0
Naptha	68	20	2.0
Napthalene	185	85	2.3
Napthalene	68	20	2.5
Napthonitrile	70	21	6.4
Napthtyl Ethyl Ether	67	19	3.2
Nitric Acid	57	14	40.0
Nitroenisole	68	20	24.0
Nitrobenzol Doxime	248	120	48.1
Nitrobenzene	68	20	36.1
Nitrobenzene	77	25	34.9
Nitrobenzene	176	80	26.3
Nitrobenzyl Alcohol	68	20	22.0
Nitroethane	68	20	19.7
Nitrogen	-203	-130	1.5
Nitromethane	68	20	39.4
Nitroglycerin	68	20	19.0
Nitrosodimethylamine	68	20	54.0
Nitrosyl Bromide	4	-16	13.4
Nitrosyl Chloride	10	-12	18.2
Nitrotoluene	68	20	25.0
Nitrous Oxide	32	0	1.6
Nonane	68	20	2.0
O-Chlorophenol	66	19	8.2

Liquids	Temperature		Dielectric Constant
	°F	°C	
Octadecanol	136	58	3.4
Octamethyltrisiloxane	68	20	2.3
Octanone	68	20	10.3
Octane	68	20	2.0
Octane	76	24	2.1
Octyl Alcohol	64	18	3.4
Octylene	65	18	4.1
Octyl Iodide	68	20	4.9
Octic Acid	68	20	2.5
Oil, Almond	68	20	2.8
Oil, Cottonseed	57	14	3.1
Oil, Grapeseed	61	16	2.9
Oil, Lemon	70	21	2.3
Oil, Linseed	55	13	3.4
Oil, Olive	68	20	3.1
Oil, Paraffin	68	20	2.2–4.7
Oil, Peanut	52	11	3.0
Oil, Petroleum	68	20	2.1
Oil, Pyranol	68	20	5.3
Oil, Sesame	55	13	3.0
Oil, Sperm	68	20	3.2
Oil, Terpentine	68	20	2.2
Oil, Transformer	68	20	2.2
Oleic Acid	68	20	2.5
Oxygen	-315	-193	1.5
Palmitic Acid	160	71	2.3
Paraffin	68	20	2.2
Paraldehyde	68	20	14.5
Peanut Oil	110	43	3.5
Pentochloroethane	60	16	3.7
Pentane	68	20	1.8
Phenethiene	68	20	2.8
Phenenthrene	230	110	2.7
Phenetidine	70	21	7.3
Phenetole	70	21	4.5
Phenol	130	54	8.8
Phenol Ether	85	29	9.8
Phenol Isobuthyl	85	29	14.9
Phenoxyacetylene	76	24	4.8
Phenylacetaldehyde	68	20.	4.8
Phenylacetanitrile	80	27	18.0
Phenylacetate	68	20	6.9
Phenylacetic	68	20	3.0
Phenylethanol	68	20	13.0
Phenylethyl Acetate	58	14	4.5
Phenylisocyanate	68	20	8.9
Phenyliso-Thiocyanate	68	20	10.7
Phosgene	32	0	4.7
Phenyl-1-Iropane	68	20	2.7
Phosphine	–76	–60	2.5
Phosphorus	93	34	4.1
Phenylsolicylate	122	50	6.3
Phtholide	166	75	36.0
Pinocolin	62	17	12.8
Pinocone	75	24	7.4
Pinane	68	20	2.7
Piperidine	68	20	5.9
Propane	32	0	1.6
Propionoldehyde	62	17	18.9
Propionic Acid	66	19	3.1
Propionic Anhydride	60	16	18.0
Propionitrile	68	20	27.7
Propyl Acetate	68	20	6.3
Propyl Alcohol	68	20	21.8
Propyl Benzene	68	20	2.4
Propyl Bromide	68	20	7.2
Propyl Butyrate	68	20	4.3
Propyl Cholorformate	68	20	11.2
Propyl Ether	78	26	3.4
Propyl Formate	66	19	7.9

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Propyl Nitrate	64	18	14.2
Propyl Propionate	68	20	4.7
Propyl Volerate	65	18	4.0
Prnopylene	77	25	1.9
Pseudocumene	60	16	2.4
Pulegone	68	20	9.5
Pulezone	66	19	9.7
Pyridine	68	20	12.5
Pyroanol Oil	68	20	5.3
Quinoline	77	25	9.0
Quinoline	460	238	5.1
Safrol	70	21	3.1
Salicyladehyde	68	20	13.9
Santowax	70	21	2.3
Sealtherm 800	750	400	2.2
Sealtherm XLT	750	400	2.3
Selenium	482	250	5.4
Sesame Oil	55	13	3.0
Silicon Tetrachloride	60	16	2.4
Sodium Hydroxide	70	20	80.0
Sodium Oleate	68	20	2.7
Sorbitol	176	80	33.5
Stannic Chloride	72	22	3.2
Stearic Acid	71	160	2.3
Styrene (phenylethene)	77	25	2.4
Succinamide	72	22	2.9
Succinic Acid	78	26	2.4
Sulfur Dioxide	-4	-20	17.6
Sulfurous Oxychloride	72	22	9.1
Sulfur Monochloride	58	14	4.8
Sulfur Trioxide	64	18	3.1
Sulfuryl Chloride	72	22	10.0
Sulfur	752	400	3.4
Sulfur	245	118	3.5
Sulfur Dioxide	32	0	15.6
Sulfuric Acid	68	20	84.0
Sulfuric Oxychloride	72	22	9.2
Sulfur Trioxide	70	21	3.6
Tallow (Beef)	68	20	2.8
Tallowamine	108	42	2.6
Tartaric Acid	68	20	6.0
Tartaric Acid	58	14	35.9
Terpinene	70	21	2.7
Terpineol	68	20	2.8
Tetrobromiethone	68	20	7.1
Tetrachloroethylene	70	21	2.5
Tetradecamethylcycloheptas	68	20	2.7
Tetraethyl Silicate	68	20	4.1
Tetradecanal	100	38	4.7
Tetraethyl Amylenetetrarar	66	189	4.4
Tetraethyl Propane Tetracarboxylate	66	19	5.2
Tetraethyl Propylene Tetracarboxylate	66	19	5.2
Tetrahydro-B-Naphthol	68	20	11.0
Tetratriocontadiene	70	21	2.8
Tetronitrimethane	68	20	2.2
Thioacetic Acid	68	20	13.0
Thionyl Bromide	68	20	9.1
Thionyl Chloride	68	20	9.3
Thiophene	68	20	2.8
Thiophosphoryl Chloride	70	21	5.8
Tin Tetrochloride	68	20	2.9
Titanium Tetrochloride	68	20	2.8
Thujone	32	0	10.0
Toluene	68	20	2.4
Toluidine	68	20	6.0
Tolunitrile	73	23	18.8
Totane	111	44	5.5
Tolyl Methyl Ether	68	20	3.5
Trans-3-Hexane	76	24	2.0
Transformer Oil	68	20	2.2

Liquids	Temperature		Dielectric Constant
	°F	°C	
Transmission Oil	80	27	2.2
Trichloroethane	68	20	7.5
Triethylamine	75	24	2.4
Triethylamine	39	4	2.9
Trifluoroacetic Acid	68	20	39.0
Trinitrotoluene	68	20	22.0
Triethyl Ethanetricarbox	66	19	6.5
Trimethyl-3-Heptane	68	20	2.2
Tribomopropane	68	20	6.4
Tributylphosphate	86	30	8.0
Trichloroacetic Acid	141	61	4.5
Trichlorotoluene	70	21	6.9
Trichloroethylene	61	16	3.4
Trichloropropane	76	24	2.4
Tricosanane	176	80	4.0
Tricosyl Phosphate	104	40	6.9
Triethyl Aconitate	68	20	6.4
Triethylamine	70	21	3.2
Triethylene Glycol (TEG)	70	21	24.2
Triethyl Aluminum	68	20	2.9
Triethyl Isoaconitate	68	20	7.2
Trifluoroactic Acid	68	20	39.0
Trifluorotoluene	86	30	9.2
Triethylomine	39	4	2.9
Trimethylbenzene	68	20	2.3
Trimethylborate	68	20	8.2
Trimethylbutane	68	20	1.9
Trimethylpentane	68	20	2.0
Trimethylsulfanilic Acid	64	18	89.0
Trinitrobenzene	68	20	2.2
Trinitrotoluene	69	21	22.0
Triolein	76	24	3.2
Tripolmitin	140	60	2.9
Triphenylmethane	212	100	2.5
Tristearin	158	70	2.8
Turpentine	68	20	2.2
Undecane	68	20	2.0
Undecanone	58	14	8.4
Urea	71	22	3.5
Urethane	74	23	3.2
Valaraldehyde	58	14	11.8
Valeric Acid	62	17	2.6
Valeronitrile	70	21	17.7
Vanadium Oxybromide	78	26	3.6
Vanadium Oxychloride	78	26	3.4
Vanadium Tetrachloride	78	26	3.0
Vegetable Oil	100	38	4.0
Vegetable Oil	230	110	3.3
Veratrol	73	23	4.5
Vinyl Ether	68	20	3.9
Water	32	0	88.0
Water	68	20	80.0
Water	212	100	48.0
Water (Ultra-Clean, DI)	68	20	12–15
Wax	100	38	7.5
Xylene	68	20	2.4
Xylenol	62	17	3.9
Xylidine	68	20	5.0

Properties: Dielectric Constants of Solids

Material	Dielectric Constant
Acetamide	41.0
Acetanilide	2.8
Acetic Acid	4.1
Aluminum Phosphate	6.0
Ammonium Bromide	7.2
Ammonium Chloride	7.0
Antimony Trichloride	5.3
Asbestos	4.8
Asphalt	2.7
Bakelite	5.0
Barium Chloride	11.0
Barium Chloride	9.4
Barium Nitrate	5.8
Barium Sulfate	11.4
Calcium Carbonate	9.1
Calcium Fluoride	7.4
Calcium Sulfate	5.6
Cellulose	4.0
Cellulose Acetate	3.6–7.5
Cement	1.5–2.1
Cereals	3.0–5.0
Charcoal	1.2–1.8
Cupric Oleafe	2.8
Cupric Oxide	18.1
Cupric Sulfate	10.3
Diamond	10.0
Diphenylethane	2.7
Dolomite	8.0
Ferrous Oxide	14.2
Fly Ash	1.9–2.6
Glass	3.7–4.2
Iodine	4.0
Lead Acetate	2.5
Lead Carbonate	18.1
Lead Chloride	4.2
Lead Nomoxide	25.9
Lead Nitrate	37.7
Lead Oleate	3.3
Lead Oxide	25.9
Lead Sulfate	14.3
Magnesium Oxide	9.7
Malachite	7.2
Mercuric Chloride	3.2
Mercurous Chloride	9.4
Mica	7.0
Napthalane	2.5

Material	Dielectric Constant
Nylon	3.7
Paper	2.0
Paraffin	2.2
Phenonthrene	2.8
Phenol	4.3
Phosphorus, Red	4.1
Phosphorus, Yellow	3.6
Polyethylene	4.0–5.0
Polypropylene	1.5
Porcelain	5.0–7.0
Potassium Aluminum Sulphate	3.8
Potassium Carbonate	5.6
Potassium Chlorate	5.1
Potassium Chloride	5.0
Potassium Chloronate	7.3
Potassium Iodide	5.6
Potassium Nitrate	5.0
Potassium Sulfate	5.9
Quartz	4.4
Resorcinol	3.2
Rice	3.5
Rubber	3.0
Sand	3.0–5.0
Selinium	11.0
Shellac	3.5
Silver Bromide	12.2
Silver Chloride	11.2
Silver Cyanide	5.6
Slate	7.0
Sodium Carbonate	8.4
Sodium Carbonate	5.3
Sodium Chloride	6.1
Sodium Nitrate	5.2
Sodium Oleate	2.8
Sodium Perchlorate	5.4
Sulfur	3.4
Sugar	3.0
Sucrose	3.3
Tantalum Oxide	11.6
Thallium Chloride	46.9
Thorium Oxide	10.6
P-Toluidine	3.0
Urea	3.5
Zinc Sulfide	8.2
Zirconium Oxide	12.5
Teflon	2.0

Properties: Viscosity of Gases and Vapors

The curves for hydrocarbon vapors and natural gases in the chart at the upper right are taken from Maxwell; the curves for all other gases (except helium) in the chart are based upon Sutherland's formula, as follows:

$$\mu = \mu_o \left(\frac{0.555\ T_o + C}{0.555\ T + C}\right)\left(\frac{T}{T_o}\right)^{3/2}$$

where:

μ = viscosity, in centipoise at temperature T.

μ_o = viscosity, in centipoise at temperature T_o.

T = absolute temperature, in degrees Rankine (460 + deg. F) for which viscosity is desired.

T_o = absolute temperature, in degrees Rankine, for which viscosity is known.

C = Sutherland's constant.

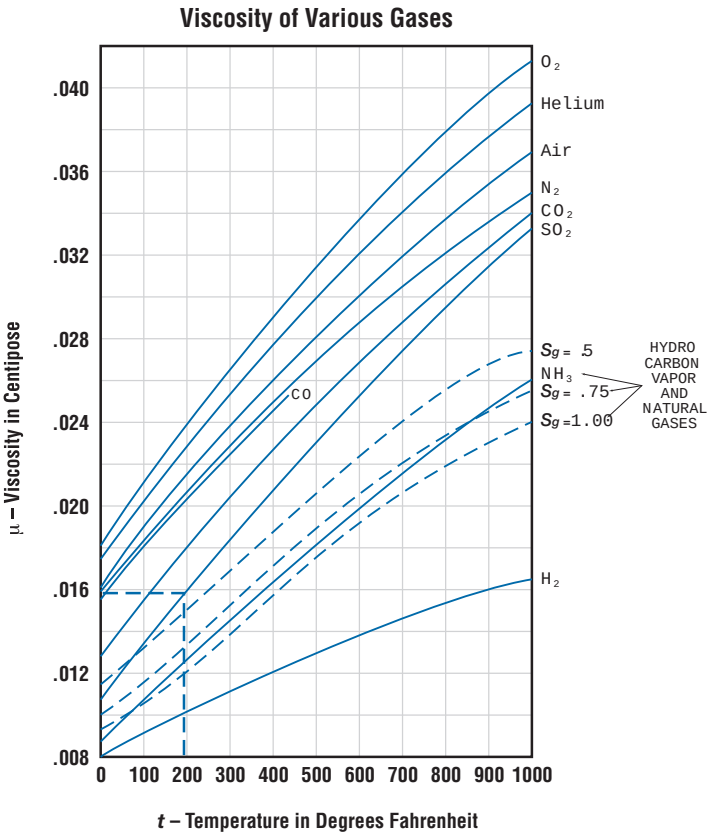
Note: The variation of viscosity with pressure is small for most gases. For gases given on this page, the correction of viscosity for pressure is less than 10% for pressures up to 500 pounds per square inch.

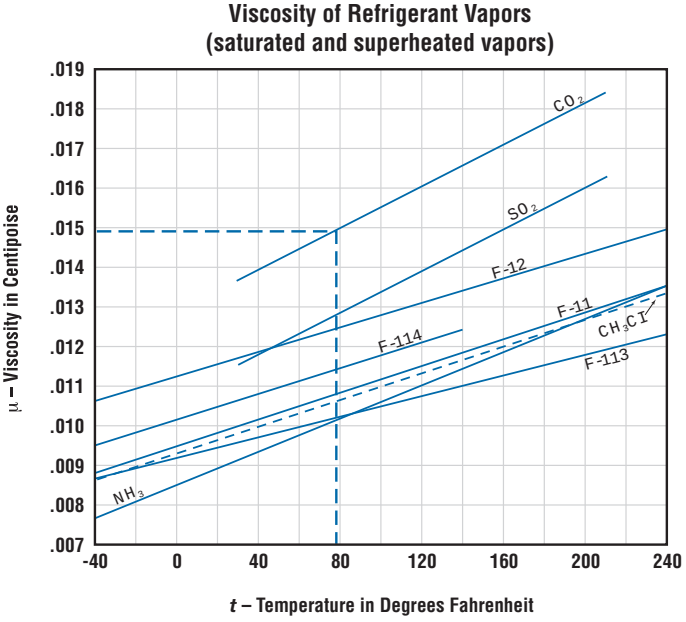
Fluid	Approximate Values of "C"
O_2	127
Air	120
N_2	111
CO_2	240
CO	118
SO_2	416
NH_3	370
H_2	72

Upper chart example: The viscosity of sulphur dioxide gas (SO_2) at 200°F (93°C) is 0.016 centipoise.

Lower chart example: The viscosity of carbon dioxide gas (CO_2) at about 80°F (26.7°) is 0.015 centipoise.

Viscosity of various gases





Properties: Viscosity of Water and Steam

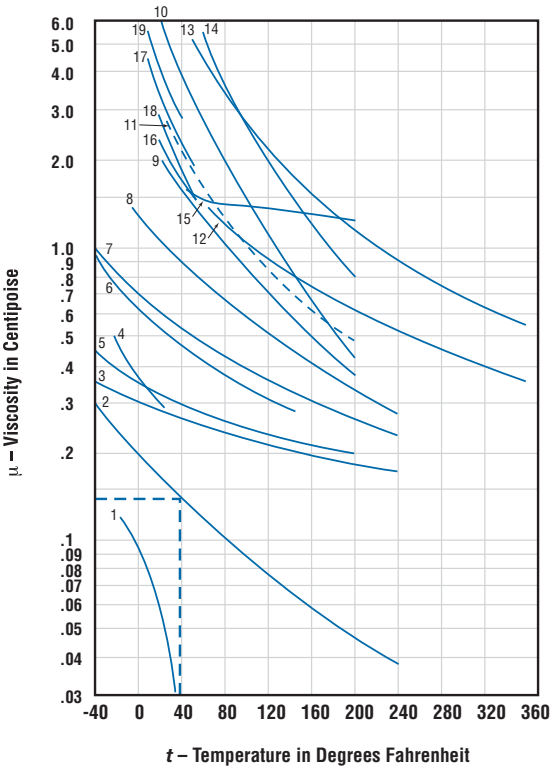
Temperature °F (°C)	Viscosity of Water and Steam – in Centipoise (μ)									
	1 PSIA	2 PSIA	5 PSIA	10 PSIA	20 PSIA	50 PSIA	100 PSIA	200 PSIA	500 PSIA	1000 PSIA
Saturated Water	.667	.524	.388	.313	.255	.197	.164	.138	.111	.094
Saturated Steam	.010	.010	.011	.012	.012	.013	.014	.015	.017	.019
1000 (538)	.030	.030	.030	.030	.030	.030	.030	.030	.030	.031
950 (510)	.029	.029	.029	.029	.029	.029	.029	.029	.029	.030
900 (482)	.028	.028	.028	.028	.028	.028	.028	.028	.028	.028
850 (454)	.026	.026	.026	.026	.026	.026	.027	.027	.027	.027
800 (427)	.025	.025	.025	.025	.025	.025	.025	.025	.026	.026
750 (399)	.024	.024	.024	.024	.024	.024	.024	.024	.025	.025
700 (371)	.023	.023	.023	.023	.023	.023	.023	.023	.023	.024
650 (343)	.022	.022	.022	.022	.022	.022	.022	.022	.023	.023
600 (316)	.021	.021	.021	.021	.021	.021	.021	.021	.021	.021
550 (288)	.020	.020	.020	.020	.020	.020	.020	.020	.020	.019
500 (260)	.019	.019	.019	.019	.019	.019	.019	.018	.018	.103
450 (232)	.018	.018	.018	.018	.017	.017	.017	.017	.115	.116
400 (204)	.016	.016	.016	.016	.016	.016	.016	.016	.131	.132
350 (177)	.015	.015	.015	.015	.015	.015	.015	.152	.153	.154
300 (149)	.014	.014	.014	.014	.014	.014	.182	.183	.183	.184
250 (121)	.013	.013	.013	.013	.013	.228	.228	.228	.228	.229
200 (93)	.012	.012	.012	.012	.300	.300	.300	.300	.300	.301
150 (66)	.011	.011	.427	.427	.427	.427	.427	.427	.427	.428
100 (37.8)	.680	.680	.680	.680	.680	.680	.680	.680	.680	.680
50 (10)	1.299	1.299	1.299	1.299	1.299	.1299	1.299	1.299	1.299	1.298
32 (0)	1.753	1.763	1.753	1.753	1.753	1.753	1.753	1.752	1.751	1.749

Values below the line are for water.

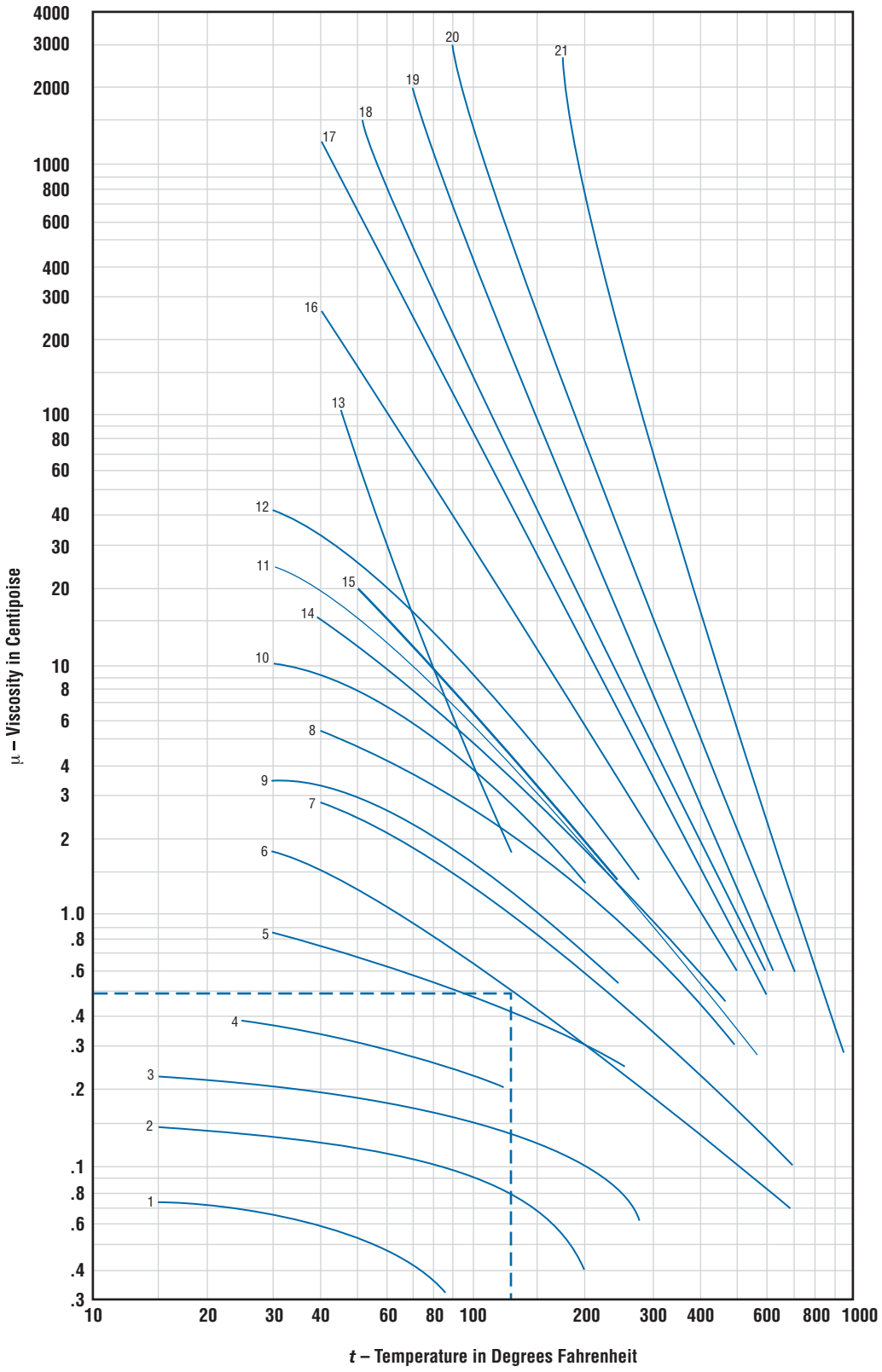
Properties: Viscosity of Various Liquids

1. Carbon Dioxide ..... CO_2
2. Ammonia ..... NH_3
3. Methyl Chloride ..... CH_3Cl
4. Sulphur Dioxide ..... SO_2
5. Freon 12 ..... F-12
6. Freon 114 ..... F-114
7. Freon 11 ..... F-11
8. Freon 113 ..... F-113
9. Ethyl Alcohol ..... C_2H_5OH
10. Isopropyl Alcohol ..... $(CH_3)_2\ CH_20$
11. 20% Sulphuric Acid ..... 20% H_2SO_4
12. Dowtherm E
13. Dowtherm A
14. 20% Sodium Hydroxide ..... 20% NaOH
15. Mercury ..... Hg
16. 10% Sodium Chloride Brine ..... 10% NaCl
17. 20% Sodium Chloride Brine ..... 20% NaCl
18. 10% Calcium Chloride Brine ..... 10% $CaCl_2$
19. 20% Calcium Chloride Brine ..... 20% $CaCl_2$

Example: The viscosity of ammonia at 40°F is 0.14 centipoise.



Properties: Viscosity of Liquid Petroleum Products

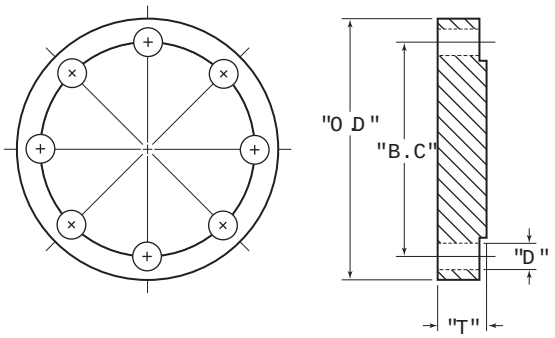


1. Ethane (C_2H_6)
2. Propane (C_3H_8)
3. Butane (C_4H_{10})
4. Natural Gasoline
5. Gasoline
6. Water
7. Kerosene
8. Distillate
9. 48 Deg. API Crude
10. 40 Deg. API Crude
11. 35.6 Deg. API Crude
12. 32.6 Deg. API Crude
13. Salt Creek Crude
14. Fuel 3 (Max.)
15. Fuel 5 (Min.)
16. SAE 10 Lube (100 V.I.)
17. SAE 30 Lube (100 V.I.)
18. Fuel 5 (Max.) or Fuel 6 (Min.)
19. SAE 70 Lube (100 V.I.)
20. Bunker C Fuel (Max.) and M.C. Residuum
21. Asphalt

Example: The viscosity of water at 125°F is 0.52 centipoise (Curve No. 6).

Note: Consult factory whenever viscosity of fluid exceeds 300 centipoise.

Pipe Data: Dimensions of Blind Flanges



NOTE: Pressure ratings shown for forged steel flanges apply to all ASA/ANSI standard flanges.

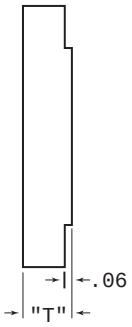
Cast Iron–125#					
Nominal Pipe Size	Outside Dia. of Flange "O.D"	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
1"	4¼"	7/16"	3⅛"	4	⅝"
1½"	5"	9/16"	3⅞"	4	⅝"
2"	6"	⅝"	4¾"	4	¾"
2½"	7"	11/16"	5½"	4	¾"
3"	7½"	¾"	6"	4	¾"
3½"	8½"	13/16"	7"	8	¾"
4"	9"	15/16"	7½"	8	¾"
5"	10"	15/16"	8½"	8	⅞"
6"	11"	1"	9½"	8	⅞"
8"	13½"	1⅛"	11¾"	8	⅞"

Cast Iron–250#					
Nominal Pipe Size	Outside Dia. of Flange "O.D"	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
1"	4⅞"	11/16"	3½"	4	¾"
1½"	6⅛"	13/16"	4½"	4	⅞"
2"	6½"	⅞"	5"	8	¾"
2½"	7½"	1"	5⅞"	8	⅞"
3"	8¼"	1⅛"	6⅝"	8	⅞"
3½"	9"	1 3/16"	7¼"	8	⅞"
4"	10"	1¼"	7⅞"	8	⅞"
5"	11"	1⅜"	9¼"	8	⅞"
6"	12½"	1 7/16"	10⅝"	12	⅞"
8"	15"	1⅝"	13"	12	1"

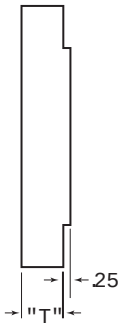
Forged Steel – 150#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	3½"	7/16"	2⅜"	4	⅝"
¾"	3⅞"	½"	2¾"	4	⅝"
1"	4¼"	9/16"	3⅛"	4	⅝"
1½"	5"	11/16"	3⅞"	4	⅝"
2"	6"	¾"	4¾"	4	¾"
2½"	7"	⅞"	5½"	4	¾"
3"	7½"	15/16"	6"	4	¾"
3½"	8½"	15/16"	7"	8	¾"
4"	9"	15/16"	7½"	8	¾"
5"	10"	15/16"	8½"	8	⅞"
6"	11"	1"	9½"	8	⅞"
8"	13½"	1⅛"	11¾"	8	⅞"

Forged Steel – 300#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	3¾"	9/16"	2⅝"	4	⅝"
¾"	4⅝"	⅝"	3¼"	4	¾"
1"	4⅞"	11/16"	3½"	4	¾"
1½"	6⅛"	13/16"	4½"	4	⅞"
2"	6½"	⅞"	5"	8	¾"
2½"	7½"	1"	5⅞"	8	⅞"
3"	8¼"	1⅛"	6⅝"	8	⅞"
3½"	9"	1 3/16"	7¼"	8	⅞"
4"	10"	1¼"	7⅞"	8	⅞"
5"	11"	1⅜"	9¼"	8	⅞"
6"	12½"	1 7/16"	10⅝"	12	⅞"
8"	15"	1⅝"	13"	12	1"

Forged Steel – 600#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	3¾"	9/16"	2⅝"	4	⅝"
¾"	4⅝"	⅝"	3¼"	4	¾"
1"	4⅞"	11/16"	3½"	4	¾"
1½"	6⅛"	⅞"	4½"	4	⅞"
2"	6½"	1"	5"	8	¾"
2½"	7½"	1⅛"	5⅞"	8	⅞"
3"	8¼"	1¼"	6⅝"	8	⅞"
3½"	9"	1 3/16"	7¼"	8	1"
4"	10¾"	1½"	8½"	8	1"
5"	13"	1¾"	10½"	8	1⅛"
6"	14"	1⅞"	1½"	12	1⅛"
8"	16½"	2 3/16"	13¾"	12	1¼"



150# & 300#



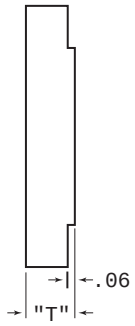
600# & above

Pipe Data: Dimensions of Blind Flanges

Forged Steel – 900#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	4¾"	⅞"	3¼"	4	⅞"
¾"	5⅛"	1"	3½"	4	⅞"
1"	5⅞"	1⅛"	4"	4	1"
1½"	7"	1¼"	4⅞"	4	1⅛"
2"	8½"	1½"	6½"	8	1"
2½"	9⅝"	1⅝"	7½"	8	1⅛"
3"	9½"	1½"	7½"	8	1"
4"	11½"	1¾"	9¼"	8	1¼"
5"	13¾"	2"	11"	8	1⅜"
6"	15"	2 3/16"	12½"	12	1¼"
8"	18½"	2½"	15½"	12	1½"

Forged Steel – 1500#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	4¾"	⅞"	3¼"	4	⅞"
¾"	5⅛"	1"	3½"	4	⅞"
1"	5⅞"	1⅛"	4"	4	1"
1½"	7"	1¼"	4⅞"	4	1⅛"
2"	8½"	1½"	6½"	8	1"
2½"	9⅝"	1⅝"	7½"	8	1⅛"
3"	10½"	1⅞"	8"	8	1¼"
4"	12¼"	2⅛"	9½"	8	1⅜"
5"	14¾"	2⅞"	11½"	8	1⅝"
6"	15½"	3¼"	12½"	12	1½"
8"	19"	3⅝"	15½"	12	1¾"

Forged Steel – 2500#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	5¼"	1 3/16"	3½"	4	⅞"
¾"	5½"	1¼"	3¾"	4	⅞"
1"	6¼"	1⅜"	4¼"	4	1"
1½"	8"	1¾"	5¾"	4	1¼"
2"	9¼"	2"	6¾"	8	1⅛"
2½"	10½"	2¼"	7¾"	8	1¼"
3"	12"	2⅝"	9"	8	1⅜"
4"	14"	3"	10¾"	8	1⅝"
5"	16½"	3⅝"	12¾"	8	1⅞"
6"	19"	4¼"	14½"	8	2⅛"
8"	21¾"	5"	17¼"	12	2⅛"



150# & 300#

600# & above

Pipe Data: Flange Ratings

Flanges DIN versus ANSI

Pressure Rating		Sizes	
ANSI	DIN	ANSI	DIN
125 lbs.	PN 6 / PN 10	1"	DN 25
150 lbs.	PN 16	1½"	DN 40
300 lbs.	PN 25 / PN 40	2"	DN 50
400 lbs.	PN 64	2½"	DN 65
600 lbs.	PN 100	3"	DN 80
900 lbs.	PN 150	4"	DN 100
1500 lbs.	PN 250	5"	DN 125
2500 lbs.	PN 320 / PN 400	6"	DN 150

Type

Flat Face = Form B flange
Raised Face = Form C flange (Form E is smoother facing finish)
Ring Joint Flange = Only for ANSI flanges

A DIN flange is never identical to an ANSI flange; the table at left is a guideline to find the most equivalent ANSI/DIN flange. DIN increments differ from country to country, the table refers to the German DIN standard.

Class 150 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	275	230	275	275	275	275	285	290	265	290	290	290	290	290	275	290	230	185	-20 to 100
200	230	195	245	235	250	255	260	260	260	260	260	260	260	260	255	260	200	185	200
300	205	175	225	215	230	230	230	230	230	230	230	230	230	230	230	230	190	185	300
400	190	160	200	195	200	200	200	200	200	200	200	200	200	200	200	200	180	185	400
500	170	150	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	500
600	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	600
650	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	-	650
700	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	-	700
750	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	-	750
800	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	-	800
850	65	65	65	65	65	65	65	-	65	65	65	65	-	65	65	65	65	-	850
900	50	-	50	50	50	50	50	-	50	50	50	50	-	50	50	50	50	-	900
950	35	-	35	35	35	35	35	-	35	35	35	35	-	35	35	35	-	-	950
1000	20	-	20	20	20	20	20	-	20	20	20	20	-	20	20	20	-	-	1000

Pipe Data: Flange Ratings (cont.)

Class 300 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	720	600	720	720	720	720	740	750	695	750	750	750	750	750	720	750	600	480	-20 to 100
200	600	510	635	620	650	660	680	740	695	750	750	750	750	750	665	750	525	480	200
300	540	455	580	560	595	615	655	710	685	720	730	730	730	730	640	730	490	480	300
400	495	420	540	515	550	575	635	680	660	695	705	705	705	700	620	705	475	480	400
500	465	395	515	480	515	540	605	655	640	665	665	665	665	665	600	665	475	455	500
600	440	370	495	450	485	515	570	605	605	605	605	605	605	605	590	605	475	415	600
650	430	365	485	440	475	505	550	590	590	590	590	590	590	590	580	590	475	-	650
700	420	360	480	435	465	495	530	570	570	570	570	570	570	570	570	570	470	-	700
750	415	355	470	425	460	490	505	530	530	530	530	530	530	530	530	530	465	-	750
800	405	345	465	420	450	485	410	510	510	510	510	510	510	510	510	510	460	-	800
850	395	340	460	420	445	485	320	-	485	485	485	485	-	485	485	485	375	-	850
900	390	-	450	415	440	450	230	-	450	450	450	450	-	450	450	450	275	-	900
950	380	-	385	385	385	385	135	-	280	320	385	385	-	385	385	365	-	-	950
1000	355	-	365	365	365	365	85	-	165	215	265	365	-	365	365	240	-	-	1000
1050	325	-	355	360	360	360	-	-	-	145	175	360	-	360	360	155	-	-	1050
1100	255	-	260	305	310	325	-	-	-	95	110	300	-	325	325	105	-	-	110
1150	205	-	190	235	235	275	-	-	-	65	70	225	-	275	275	75	-	-	1150
1200	165	-	135	185	186	205	-	-	-	40	40	145	-	205	205	70	-	-	1200
1250	135	-	105	145	140	180	-	-	-	-	-	-	-	165	145	-	-	-	1250
1300	115	-	75	115	110	140	-	-	-	-	-	-	-	120	70	-	-	-	1300
1350	95	-	60	95	85	105	-	-	-	-	-	-	-	-	55	-	-	-	1350
1400	75	-	45	75	65	75	-	-	-	-	-	-	-	-	40	-	-	-	1400
1450	60	-	35	60	50	60	-	-	-	-	-	-	-	-	35	-	-	-	1450
1500	40	-	25	40	40	40	-	-	-	-	-	-	-	-	25	-	-	-	1500

Class 600 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	1440	1200	1440	1440	1440	1440	1480	1500	1395	1500	1500	1500	1500	1500	1440	1500	1200	960	-20 to 100
200	1200	1020	1270	1240	1295	1325	1360	1485	1395	1500	1500	1500	1500	1500	1330	1500	1050	960	200
300	1075	910	1160	1120	1190	1235	1310	1420	1375	1445	1455	1455	1455	1455	1275	1455	980	960	300
400	995	840	1085	1025	1105	1150	1265	1365	1325	1385	1410	1410	1410	1395	1240	1410	945	960	400
500	930	785	1025	955	1030	1085	1205	1310	1285	1330	1330	1330	1330	1330	1205	1330	945	905	500
600	885	745	990	900	975	1030	1135	1210	1210	1210	1210	1210	1210	1210	1175	1210	945	825	600
650	865	730	970	885	950	1015	1100	1175	1175	1175	1175	1175	1175	1175	1155	1175	945	-	650
700	845	720	955	870	930	995	1060	1135	1135	1135	1135	1135	1135	1135	1135	1135	940	-	700
750	825	705	940	855	915	985	1015	1065	1065	1065	1065	1065	1065	1065	1065	1065	930	-	750
800	810	690	930	845	900	975	825	1015	1015	1015	1015	1015	1015	1015	1015	1015	915	-	800
850	790	675	915	835	895	970	640	-	975	975	975	975	-	975	975	975	755	-	850
900	780	-	900	830	885	900	460	-	900	900	900	900	-	900	900	900	550	-	900
950	765	-	775	775	775	775	275	-	560	640	775	775	-	775	775	725	-	-	950
1000	710	-	725	725	725	725	170	-	330	430	535	725	-	725	725	480	-	-	1000
1050	650	-	705	720	720	720	-	-	-	290	350	720	-	720	720	310	-	-	1050
1100	515	-	520	610	625	645	-	-	-	190	220	605	-	645	645	205	-	-	1100
1150	410	-	375	475	475	550	-	-	-	130	135	445	-	550	550	150	-	-	1150
1200	330	-	275	370	320	410	-	-	-	80	80	290	-	410	410	135	-	-	1200
1250	265	-	205	295	280	365	-	-	-	-	-	-	-	330	290	-	-	-	1250
1300	225	-	150	235	220	275	-	-	-	-	-	-	-	240	135	-	-	-	1300
1350	185	-	115	190	170	205	-	-	-	-	-	-	-	-	110	-	-	-	1350
1400	150	-	90	150	130	150	-	-	-	-	-	-	-	-	75	-	-	-	1400
1450	115	-	65	115	105	115	-	-	-	-	-	-	-	-	70	-	-	-	1450
1500	85	-	50	85	75	85	-	-	-	-	-	-	-	-	55	-	-	-	1500

Pipe Data: Flange Ratings (cont.)

Class 900 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	2160	1800	2160	2160	2160	2160	2220	2250	2090	2250	2250	2250	2250	2250	2160	2250	1800	1440	-20 to 100
200	1800	1535	1910	1860	1945	1985	2035	2225	2090	2250	2250	2250	2250	2250	1995	2250	1575	1440	200
300	1615	1370	1740	1680	1785	1850	1965	2130	2060	2165	2185	2185	2185	2185	1915	2185	1470	1440	300
400	1490	1260	1625	1540	1655	1730	1900	2045	1985	2080	2115	2115	2115	2095	1860	2115	1420	1440	400
500	1395	1180	1540	1435	1545	1625	1810	1965	1925	1995	1995	1995	1995	1995	1805	1995	1420	1360	500
600	1325	1115	1485	1355	1460	1550	1705	1815	1815	1815	1815	1815	1815	1815	1765	1815	1420	1240	600
650	1295	1095	1455	1325	1425	1520	1650	1765	1765	1765	1765	1765	1765	1765	1735	1765	1420	-	650
700	1265	1080	1435	1305	1395	1490	1590	1705	1705	1705	1705	1705	1705	1705	1705	1705	1410	-	700
750	1240	1060	1410	1280	1375	1475	1520	1595	1595	1595	1595	1595	1595	1595	1595	1595	1395	-	750
800	1215	1035	1395	1265	1355	1460	1235	1525	1525	1525	1525	1525	1520	1525	1525	1525	1375	-	800
850	1190	1015	1375	1255	1340	1455	955	-	1460	1460	1460	1460	-	1460	1460	1460	1130	-	850
900	1165	-	1350	1245	1325	1350	690	-	1350	1350	1350	1350	-	1350	1350	1350	825	-	900
950	1145	-	1160	1160	1160	1160	410	-	845	955	1160	1160	-	1160	1160	1090	-	-	950
1000	1065	-	1090	1090	1090	1090	255	-	495	650	800	1090	-	1090	1090	720	-	-	1000
1050	975	-	1060	1080	1080	1080	-	-		430	525	1080	-	1080	1080	465	-	-	1050
1100	770	-	780	915	935	965	-	-	-	290	330	905	-	965	965	310	-	-	1100
1150	615	-	565	710	710	825	-	-	-	195	205	670	-	825	825	225	-	-	1150
1200	495	-	410	555	555	620	-	-	-	125	125	430	-	615	620	205	-	-	1200
1250	400	-	310	440	420	545	-	-	-	-	-	-	-	495	430	-	-	-	1250
1300	340	-	225	350	330	410	-	-	-	-	-	-	-	360	205	-	-	-	1300
1350	280	-	175	290	255	310	-	-	-	-	-	-	-	-	165	-	-	-	1350
1400	225	-	135	225	195	225	-	-	-	-	-	-	-	-	115	-	-	-	1400
1450	175	-	100	175	155	175	-	-	-	-	-	-	-	-	105	-	-	-	1450
1500	125	-	75	125	115	125	-	-	-	-	-	-	-	-	80	-	-	-	1500

Class 1500 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	3600	3000	3600	3600	3600	3600	3705	3750	3480	3750	3750	3750	3750	3750	3600	3750	3000	2400	-20 to 200
200	3000	2555	3185	3095	3240	3310	3395	3710	3480	3750	3750	3750	3750	3750	3325	3750	2630	2400	200
300	2690	2280	2905	2795	2975	3085	3270	3550	3435	3610	3640	3640	3640	3640	3190	3640	2450	2400	300
400	2485	2100	2710	2570	2760	2880	3170	3410	3310	3465	3530	3530	3530	3490	3095	3530	2365	2400	400
500	2330	1970	2270	2390	2580	2710	3015	3275	3210	3325	3325	3325	3325	3325	3010	3325	2365	2270	500
600	2210	1860	2470	2255	2435	2580	2840	3025	3025	3025	3025	3025	3025	3025	2940	3025	2365	2065	600
650	2160	1825	2425	2210	2375	2530	2745	2940	2940	2940	2940	2940	2940	2940	2890	2940	2365	-	650
700	2110	1800	2390	2170	2330	2485	2655	2840	2840	2840	2840	2840	2840	2840	2840	2840	2350	-	700
750	2065	1765	2350	2135	2290	2460	2535	2660	2660	2660	2660	2660	2660	2660	2660	2660	2330	-	750
800	2030	1730	2330	2110	2255	2435	2055	2540	2540	2540	2540	2540	2540	2540	2540	2540	2290	-	800
850	1980	1690	2290	2090	2230	2425	1595	-	2435	2435	2435	2435	-	2435	2435	2435	1885	-	850
900	1945	-	2245	2075	2210	2245	1150	-	2245	2245	2245	2245	-	2245	2245	2245	1370	-	900
950	1910	-	1930	1930	1930	1930	685	-	1405	1595	1930	1930	-	1930	1930	1815	-	-	950
1000	1770	-	1820	1820	1820	1820	430	-	825	1080	1335	1820	-	1820	1820	1200	-	-	1000
1050	1630	-	1765	1800	1800	1800	-	-	-	720	875	1800	-	1800	1800	770	-	-	1050
1100	1285	-	1305	1525	1560	1610	-	-	-	480	550	1510	-	1610	1610	515	-	-	1100
1150	1030	-	934	1185	1185	1370	-	-	-	325	345	1115	-	1370	1370	375	-	-	1150
1200	825	-	685	925	925	1030	-	-	-	205	205	720	-	1030	1030	345	-	-	1200
1250	670	-	515	735	705	910	-	-	-	-	-	-	-	825	720	-	-	-	1250
1300	565	-	375	585	660	685	-	-	-	-	-	-	-	600	345	-	-	-	1300
1350	465	-	290	480	430	515	-	-	-	-	-	-	-	-	275	-	-	-	1350
1400	380	-	225	380	325	380	-	-	-	-	-	-	-	-	190	-	-	-	1400
1450	290	-	165	290	255	290	-	-	-	-	-	-	-	-	170	-	-	-	1450
1500	205	-	130	205	190	205	-	-	-	-	-	-	-	-	135	-	-	-	1500

Pipe Data: Flange Ratings (cont.)

Class 2500 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	6000	5000	6000	6000	6000	6000	6170	6250	5805	6250	6250	6250	6250	6250	6000	6250	5000	4000	-20 to 100
200	5000	4260	5300	5160	5400	5520	5625	6180	5805	6250	6250	6250	6250	6250	5540	6250	4380	4000	200
300	4480	3800	4840	4660	4960	5140	5450	5920	5725	6015	6070	6070	6070	6070	5320	6070	4080	4000	300
400	4140	3500	4520	4280	4600	4800	5280	5680	5520	5775	5880	5880	5880	5820	5160	5880	3940	4000	400
500	3880	3280	4280	3980	4300	4520	5025	5460	5350	5540	5540	5540	5540	5540	5020	5540	3940	3780	500
600	3680	3100	4120	3760	4060	4300	4730	5040	5040	5040	5040	5040	5040	5040	4900	5040	3940	3440	600
650	3600	3040	4040	3680	3960	4220	4575	4905	4905	4905	4905	4905	4905	4905	4820	4905	3940	-	650
700	3520	3000	3980	3620	3880	4140	4425	4730	4730	4730	4730	4730	4730	4730	4730	4730	3920	-	700
750	3440	2940	3920	3560	3820	4100	4230	4430	4430	4430	4430	4430	4430	4430	4430	4430	3880	-	750
800	3380	2880	3880	3520	3760	4060	3430	4230	4230	4230	4230	4230	4230	4230	4230	4230	3820	-	800
850	3300	2820	3820	3480	3720	4040	2655	-	4060	4060	4060	4060	-	4060	4060	4060	3145	-	850
900	3240	-	3745	3460	3680	3745	1915	-	3745	3745	3745	3745	-	3745	3745	3745	2285	-	900
950	3180	-	3220	3220	3220	3220	1145	-	2345	2655	3220	3220	-	3220	3220	3030	-	-	950
1000	2950	-	3030	3030	3030	3030	715	-	1370	1800	2230	3030	-	3030	3030	2000	-	-	1000
1050	2715	-	2945	3000	3000	3000	-	-	-	1200	1455	3000	-	3000	3000	1285	-	-	1050
1100	2145	-	2170	2545	2600	2685	-	-	-	800	915	2515	-	2685	2685	855	-	-	1100
1150	1715	-	1570	1970	1970	2285	-	-	-	545	570	1855	-	2285	2285	630	-	-	1150
1200	1370	-	1145	1545	1545	1715	-	-	-	345	345	1200	-	1715	1715	570	-	-	1200
1250	1115	-	855	1230	1170	1515	-	-	-	-	-	-	-	1370	1200	-	-	-	1250
1300	945	-	630	970	915	1145	-	-	-	-	-	-	-	1000	570	-	-	-	1300
1350	770	-	485	800	715	860	-	-	-	-	-	-	-	-	455	-	-	-	1350
1400	630	-	370	630	545	630	-	-	-	-	-	-	-	-	315	-	-	-	1400
1450	485	-	275	485	430	485	-	-	-	-	-	-	-	-	285	-	-	-	1450
1500	345	-	215	345	315	345	-	-	-	-	-	-	-	-	230	-	-	-	1500

ANSI Flange Bolting Dimensions for Stud Bolts (inches)

Nominal Pipe Size	Flange Face	ANSI Pressure Class											
		150#		300#		600#		900#		1500#		2500#	
		Diam.	Length	Diam	Length	Diam	Length	Diam	Length	Diam	Length	Diam	Length
½"	RF	½"	2.25	½"	2.50	½"	3.00	¾"	4.25	¾"	4.25	¾"	4.75
	RTJ		— —		3.00		3.00		4.25		4.25		4.75
¾"	RF	½"	2.50	⅝"	3.00	⅝"	3.50	¾"	4.50	¾"	4.50	¾"	5.00
	RTJ		— —		3.50		3.50		4.50		4.50		5.00
1"	RF	½"	2.50	⅝"	3.00	⅝"	3.50	⅞"	5.00	⅞"	5.00	⅞"	5.50
	RTJ		3.00		3.50		3.50		5.00		5.00		5.50
1¼"	RF	½"	2.75	⅝"	3.25	⅝"	3.75	⅞"	5.00	⅞"	5.00	1	6.00
	RTJ		3.25		3.75		3.75		5.00		5.00		6.00
1½"	RF	½"	2.75	¾"	3.50	¾"	4.25	1	5.50	1	5.50	1⅛"	6.75
	RTJ		3.25		4.00		4.25		5.50		5.50		6.75
2"	RF	⅝"	3.25	⅝"	3.50	⅝"	4.25	⅞"	5.75	⅞"	5.75	1	7.00
	RTJ		3.75		4.00		4.25		5.75		5.75		7.00
2½"	RF	⅝"	3.50	¾"	4.00	¾"	4.75	1	6.25	1	6.25	1⅛"	7.75
	RTJ		4.00		4.50		4.75		6.25		6.25		8.00
3	RF	⅝"	3.50	¾"	4.25	¾"	5.00	⅞"	5.75	1⅛"	7.00	1¼"	8.75
	RTJ		4.00		4.75		5.00		5.75		7.00		9.00
3½"	RF	⅝"	3.50	¾"	4.25	⅞"	5.50	— —	— —	— —	— —	— —	— —
	RTJ		4.00		5.00		5.50		— —		— —		— —
4"	RF	⅝"	3.50	¾"	4.50	⅞"	5.75	1⅛"	6.75	1¼"	7.75	1½"	10.00
	RTJ		4.00		5.00		5.75		6.75		7.75		10.25
5"	RF	¾"	3.75	¾"	4.75	1	6.50	1¼"	7.50	1½"	9.75	1¾"	11.75
	RTJ		4.25		5.25		6.50		7.50		9.75		12.25
6"	RF	¾"	4.00	¾"	4.75	1	6.75	1⅛"	7.50	1⅜"	10.25	2	16.50
	RTJ		4.50		5.50		6.75		7.75		10.50		14.00
8"	RF	¾"	4.25	⅞"	5.50	1⅛"	7.25	1⅜"	8.75	1⅝"	11.50	2	15.00
	RTJ		4.75		6.00		7.75		8.75		12.75		15.50

*3MHP Type torqued to 20 ft. ib. with Buna-N gasket

Service Ratings of Tri-Clamp Connections

	Pressure Rating (PSI)					
TEMP (°F)	1"/1.5"	2"	2.5"	3"	4"	5"
70	1500	1000	1000	1000	1000	300
250	1200	800	800	800	800	200
400	950	725	N/A	N/A	450	N/A

RF flanges 150# and 300# class, RF-0.06"; 600# and greater, RF=0.25"

Pipe Data: Plastic Flange Ratings

Temperature (°F)	Material					
	PVC	CPVC	PVDF (Kynar®)	PTFE (Teflon®)	Fiberglass (1" to 3")	Fiberglass (4")
73	150	150	150	15	450	225
100	93	127	150	13	450	225
120	60	97	150	11	450	225
140	33	75	150	10	450	225
160	—	60	133	8	450	225
180	—	37	115	—	450	225
200	—	30	97	—	450	225
220	—	—	80	—	450	225
240	—	—	60	—	—	—
260	—	—	43	—	—	—
280	—	—	25	—	—	—
300	—	—	—	—	—	—
400	—	—	—	—	—	—

Pipe Data: Cast Iron Pipe

Cast Iron Pipe–ASA Standard

Pipe Size	Pipe O.D.	Class 50 50 PSIG		Class 100 100 PSIG		Class 150 150 PSIG		Class 200 200 PSIG		Class 250 250 PSIG		Class 300 300 PSIG		Class 350 350 PSIG	
		WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.
3	3.96	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32
4	4.80	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10
6	6.90	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14
8	9.05	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23
10	11.10	0.44	10.22	0.44	10.22	0.44	10.22	0.44	10.22	0.44	10.22	0.48	10.14	0.52	10.06
12	13.20	0.48	12.24	0.48	12.24	0.48	12.24	0.48	12.24	0.52	12.16	0.51	12.16	0.56	12.08
14	15.30	0.48	14.34	0.51	14.28	0.51	14.28	0.55	14.20	0.59	14.12	0.59	14.12	0.64	14.02
16	17.40	0.54	16.32	0.54	16.32	0.54	16.32	0.58	16.24	0.63	16.14	0.68	16.04	0.68	16.04
18	19.50	0.54	18.42	0.58	18.34	0.58	18.34	0.63	18.24	0.68	18.14	0.73	18.04	0.79	17.92
20	21.60	0.57	20.46	0.62	20.36	0.62	20.36	0.67	20.26	0.72	20.16	0.78	20.04	0.84	19.92
24	25.80	0.63	24.54	0.68	24.44	0.73	24.34	0.79	24.22	0.79	24.22	0.85	24.10	0.92	23.96

Cast Iron Pipe–AWWA Standard

Pipe Size	Class A 100 Ft. 43 PSIG			Class B 200 Ft. 86 PSIG			Class C 300 Ft. 130 PSIG			Class D 400 Ft. 173 PSIG		
	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.
3	3.80	0.39	3.02	3.96	0.42	3.12	3.96	0.45	3.06	3.96	0.48	3.00
4	4.80	0.42	3.96	5.00	0.45	4.10	5.00	0.48	4.04	5.00	0.52	3.96
6	6.90	0.44	6.02	7.10	0.48	6.14	7.10	0.51	6.08	7.10	0.55	6.00
8	9.05	0.46	8.13	9.05	0.51	8.03	9.30	0.56	8.18	9.30	0.60	8.10
10	11.10	0.50	10.10	11.10	0.57	9.96	11.40	0.62	10.16	11.40	0.68	10.04
12	13.20	0.54	12.12	13.20	0.62	11.96	13.50	0.68	12.14	13.50	0.75	12.00
14	15.30	0.57	14.16	15.30	0.66	13.98	15.65	0.74	14.17	15.65	0.82	14.01
16	17.40	0.60	16.20	17.40	0.70	16.00	17.80	0.80	16.20	17.80	0.89	16.02
18	19.50	0.64	18.22	19.50	0.75	18.00	19.92	0.87	18.18	19.92	0.96	18.00
20	21.60	0.67	20.26	21.60	0.80	20.00	22.06	0.92	20.22	22.06	1.03	20.00
24	25.80	0.76	24.28	25.80	0.89	24.02	26.32	1.04	24.22	26.32	1.16	24.00
30	31.74	0.88	29.98	32.00	1.03	29.94	32.40	1.20	30.00	32.74	1.37	30.00
36	37.96	0.99	35.98	38.30	1.15	36.00	38.70	1.36	39.98	39.16	1.58	36.00
42	44.20	1.10	42.00	44.50	1.28	41.94	45.10	1.54	42.02	45.58	1.78	42.02
48	50.50	1.26	47.98	50.80	1.42	47.96	51.40	1.71	47.98	51.98	1.96	48.06
54	56.66	1.35	53.96	57.10	1.55	54.00	57.80	1.90	54.00	58.40	2.23	53.94
60	62.80	1.39	60.02	63.40	1.67	60.06	64.20	2.00	60.20	64.82	2.38	60.06
72	75.34	1.62	72.10	75.00	1.95	72.10	76.88	2.39	72.10	–	–	–
84	87.54	1.72	84.10	88.54	2.22	84.10	–	–	–	–	–	–

Pipe Size	Class E 500 Ft. 217 PSIG			Class F 600 Ft. 260 PSIG			Class G 700 Ft. 304 PSIG			Class H 800 Ft. 347 PSIG		
	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.
6	7.22	0.58	6.06	7.22	0.61	6.00	7.38	0.65	6.08	7.38	0.69	6.00
8	9.42	0.66	8.10	9.42	0.71	8.00	9.60	0.75	8.10	9.60	0.80	8.00
10	11.60	0.74	10.12	11.60	0.80	10.00	11.84	0.86	10.12	11.84	0.92	10.00
12	13.78	0.82	12.14	13.78	0.89	12.00	14.08	0.97	12.14	14.08	1.04	12.00
14	15.98	0.90	14.18	15.98	0.99	14.00	16.32	1.07	14.18	16.32	1.16	14.00
16	18.16	0.98	16.20	18.16	1.08	16.00	18.54	1.18	16.18	18.54	1.27	16.00
18	20.34	1.07	18.20	20.34	1.17	18.00	20.78	1.28	18.22	20.78	1.39	18.00
20	22.54	1.15	20.24	22.54	1.27	20.00	23.02	1.39	20.24	23.02	1.51	20.00
24	26.90	1.31	24.28	26.90	1.45	24.00	27.76	1.75	24.26	27.76	1.88	24.00
30	33.10	1.55	30.00	33.46	1.73	30.00	–	–	–	–	–	–
36	39.60	1.80	36.00	40.04	2.02	36.00	–	–	–	–	–	–

Pipe Data: Steel Pipe

Nominal Pipe Size, in.	Outside Diameter, in.	Schedule No.	Wall Thickness, in.	Inside Diameter, in.	Cross-sectional Area		Circumference, ft., or surface, ft²/ft of length		Capacity at 1-ft/s velocity		Weight of plain-end pipe, lb/ft
					Metal, in²	Flow, ft²	Outside	Inside	U.S. gal/min	lb/h water	
⅛	0.405	10S	.049	.307	.055	.00051	.106	.0804	.231	115.5	.19
		40ST, 40S	.068	.269	.072	.00040	.106	.0705	.179	89.5	.24
		80XS, 80S	.095	.215	.093	.00025	.106	.0563	.113	56.5	.31
¼	0.540	10S	.065	.410	.097	.00092	.141	.107	.412	206.5	.33
		40ST, 40S	.088	.364	.125	.00072	.141	.095	.323	161.5	.42
		80XS, 80S	.119	.302	.157	.00050	.141	.079	.224	112.0	.54
⅜	0.675	10S	.065	.545	.125	.00162	.177	.143	.727	363.5	.42
		40ST, 40S	.091	.493	.167	.00133	.177	.129	.596	298.0	.57
		80XS, 80S	.126	.423	.217	.00098	.177	.111	.440	220.0	.74
½	0.840	5S	.065	.710	.158	.00275	.220	.186	1.234	617.0	.54
		10S	.083	.674	.197	.00248	.220	.176	1.112	556.0	.67
		40ST, 40S	.109	.622	.250	.00211	.220	.163	0.945	472.0	.85
		80XS, 80S	.147	.546	.320	.00163	.220	.143	0.730	365.0	1.09
		160	.188	.464	.385	.00117	.220	.122	0.527	263.5	1.31
		XX	.294	.252	.504	.00035	.220	.066	0.155	77.5	1.71
¾	1.050	5S	.065	.920	.201	.00461	.275	.241	2.072	1036.0	0.69
		10S	.083	.884	.252	.00426	.275	.231	1.903	951.5	0.86
		40ST, 40S	.113	.824	.333	.00371	.275	.216	1.665	832.5	1.13
		80XS, 80S	.154	.742	.433	.00300	.275	.194	1.345	672.5	1.47
		160	.219	.612	.572	.00204	.275	.160	0.917	458.5	1.94
		XX	.308	.434	.718	.00103	.275	.114	0.461	230.5	2.44
1	1.315	5S	.065	1.185	.255	.00768	.344	.310	3.449	1725	0.87
		10S	.109	1.097	.413	.00656	.344	.287	2.946	1473	1.40
		40ST, 40S	.133	1.049	.494	.00600	.344	.275	2.690	1345	1.68
		80XS, 80S	.179	0.957	.639	.00499	.344	.250	2.240	1120	2.17
		160	.250	0.815	.836	.00362	.344	.213	1.625	812.5	2.84
		XX	.358	0.599	1.076	.00196	.344	.157	0.878	439.0	3.66
1¼	1.660	5S	.065	1.530	0.326	.01277	.435	.401	5.73	2865	1.11
		10S	.109	1.442	0.531	.01134	.435	.378	5.09	2545	1.81
		40ST, 40S	.140	1.380	0.668	.01040	.435	.361	4.57	2285	2.27
		80XS, 80S	.191	1.278	0.881	.00891	.435	.335	3.99	1995	3.00
		160	.250	1.160	1.107	.00734	.435	.304	3.29	1645	3.76
		XX	.382	0.896	1.534	.00438	.435	.235	1.97	985	5.21
1½	1.900	5S	.065	1.770	0.375	.01709	.497	.463	7.67	3835	1.28
		10S	.109	1.682	0.614	.01543	.497	.440	6.94	3465	2.09
		40ST, 40S	.145	1.610	0.800	.01414	.497	.421	6.34	3170	2.72
		80XS, 80S	.200	1.500	1.069	.01225	.497	.393	5.49	2745	3.63
		160	.281	1.338	1.429	.00976	.497	.350	4.38	2190	4.86
		XX	.400	1.100	1.885	.00660	.497	.288	2.96	1480	6.41
2	2.375	5S	.065	2.245	0.472	.02749	.622	.588	12.34	6170	1.61
		10S	.109	2.157	0.776	.02538	.622	.565	11.39	5695	2.64
		40ST, 40S	.154	2.067	1.075	.02330	.622	.541	10.45	5225	3.65
		80ST, 80S	.218	1.939	1.477	.02050	.622	.508	9.20	4600	5.02
		160	.344	1.687	2.195	.01552	.622	.436	6.97	3485	7.46
		XX	.436	1.503	2.656	.01232	.622	.393	5.53	2765	9.03
2½	2.875	5S	.083	2.709	0.728	.04003	.753	.709	17.97	8985	2.48
		10S	.120	2.635	1.039	.03787	.753	.690	17.00	8500	3.53
		40ST, 40S	.203	2.469	1.704	.03322	.753	.647	14.92	7460	5.79
		80XS, 80S	.276	2.323	2.254	.02942	.753	.608	13.20	6600	7.66
		160	.375	2.125	2.945	.02463	.753	.556	11.07	5535	10.01
		XX	.552	1.771	4.028	.01711	.753	.464	7.68	3840	13.69
3	3.500	5S	.083	3.334	0.891	.06063	.916	.873	27.21	13,605	3.03
		10S	.120	3.260	1.274	.05796	.916	.853	26.02	13,010	4.33
		40ST, 40S	.216	3.068	2.228	.05130	.916	.803	23.00	11,500	7.58
		80XS, 80S	.300	2.900	3.016	.04587	.916	.759	20.55	10,275	10.25
		160	.438	2.624	4.213	.03755	.916	.687	16.86	8430	14.32
		XX	.600	2.300	5.466	.02885	.916	.602	12.95	6475	18.58
3½	4.0	5S	.083	3.834	1.021	.08017	1.047	1.004	35.98	17,990	3.48
		10S	.120	3.760	1.463	.07711	1.047	0.984	34.61	17,305	4.97
		40ST, 40S	.226	3.548	2.680	.06870	1.047	0.929	30.80	15,400	9.11
		80XS, 80S	.318	3.364	3.678	.06170	1.047	0.881	27.70	13,850	12.50
4	4.5	5S	.083	4.334	1.152	.10245	1.178	1.135	46.0	23,000	3.92
		10S	.120	4.260	1.651	.09898	1.178	1.115	44.4	22,200	5.61
		40ST, 40S	.237	4.026	3.17	.08840	1.178	1.054	39.6	19,800	10.79
		80XS, 80S	.337	3.826	4.41	.07986	1.178	1.002	35.8	17,900	14.98
		120	.438	3.624	5.58	.07170	1.178	0.949	32.2	16,100	19.00
		160	.531	3.438	6.62	.06647	1.178	0.900	28.9	14,450	22.51
		XX	.674	3.152	8.10	.05419	1.178	0.825	24.3	12,150	27.54

Pipe Data: Steel Pipe (cont.)

Nominal Pipe Size, in.	Outside Diameter, in.	Schedule No.	Wall Thickness, in.	Inside Diameter, in.	Cross-sectional Area		Circumference, ft., or surface, ft²/ft of length		Capacity at 1-ft/s velocity		Weight of plain-end pipe, lb/ft
					Metal, in²	Flow, ft²	Outside	Inside	U.S. gal/min	lb/h water	
5	5.563	5S	.109	5.345	1.87	.1558	1.456	1.399	69.9	34,950	6.36
		10S	.134	5.295	2.29	.1529	1.456	1.386	68.6	34,300	7.77
		40ST, 40S	.258	5.047	4.30	.1390	1.456	1.321	62.3	31,150	14.62
		80SX, 80S	.375	4.813	6.11	.1263	1.456	1.260	57.7	28,850	20.78
		120	.500	4.563	7.95	.1136	1.456	1.195	51.0	25,500	27.04
		160	.625	4.313	9.70	.1015	1.456	1.129	45.5	22,750	32.96
		XX	.750	4.063	11.34	.0900	1.456	1.064	40.4	20,200	38.55
6	6.625	5S	.109	6.407	2.23	.2239	1.734	1.677	100.5	50,250	7.60
		10S	.134	6.357	2.73	.2204	1.734	1.664	98.9	49,450	9.29
		40ST, 40S	.280	6.065	5.58	.2006	1.734	1.588	90.0	45,000	18.97
		80XS, 80S	.432	5.761	8.40	.1810	1.734	1.508	81.1	40,550	28.57
		120	.562	5.501	10.70	.1650	1.734	1.440	73.9	36,950	36.39
		160	.719	5.187	13.34	.1467	1.734	1.358	65.9	32,950	45.34
		XX	.864	4.897	15.64	.1308	1.734	1.282	58.7	29,350	53.16
8	8.625	5S	.109	8.407	2.915	.3855	2.258	2.201	173.0	86,500	9.93
		10S	.148	8.329	3.941	.3784	2.258	2.180	169.8	84,900	13.40
		20	.250	8.125	6.578	.3601	2.258	2.217	161.5	80,750	22.36
		30	.277	8.071	7.265	.3553	2.258	2.113	159.4	79,700	24.70
		40ST, 40S	.322	7.981	8.399	.3474	2.258	2.089	155.7	77,850	28.55
		60	.406	7.813	10.48	.3329	2.258	2.045	149.4	74,700	35.64
		80XS, 80S	.500	7.625	12.76	.3171	2.258	1.996	142.3	71,150	43.39
		100	.594	7.437	14.99	.3017	2.258	1.947	135.4	67,700	50.95
		120	.719	7.187	17.86	.2817	2.258	1.882	126.4	63,200	60.71
		140	.812	7.001	19.93	.2673	2.258	1.833	120.0	60,000	67.76
		XX	.875	6.875	21.30	.2578	2.258	1.800	115.7	57,850	72.42
		160	.906	6.813	21.97	.2532	2.258	1.784	113.5	56,750	74.69
10	10.75	5S	.134	10.482	4.47	.5993	2.814	2.744	269.0	134,500	15.19
		10S	.165	10.420	5.49	.5922	2.814	2.728	265.8	132,900	18.65
		20	.250	10.250	8.25	.5731	2.814	2.685	257.0	128,500	28.04
		30	.307	10.136	10.07	.5603	2.814	2.655	252.0	126,000	34.24
		40ST, 40S	.365	10.020	11.91	.5475	2.814	2.620	246.0	123,000	40.48
		80S, 60XS	.500	9.750	16.10	.5185	2.814	2.550	233.0	116,500	54.74
		80	.594	9.562	18.95	.4987	2.814	2.503	223.4	111,700	64.43
		100	.719	9.312	22.66	.4729	2.814	2.438	212.3	106,150	77.03
		120	.844	9.062	26.27	.4479	2.814	2.372	201.0	100,500	89.29
		140, XX	1.000	8.750	30.63	.4176	2.814	2.291	188.0	94,000	104.13
		160	1.125	8.500	34.02	.3941	2.814	2.225	177.0	88,500	115.64
12	12.75	5S	0.156	12.438	6.17	.8438	3.338	3.26	378.7	189,350	20.98
		10S	0.180	12.390	7.11	.8373	3.338	3.24	375.8	187,900	24.17
		20	0.250	12.250	9.82	.8185	3.338	3.21	367.0	183,500	33.38
		30	0.330	12.090	12.88	.7972	3.338	3.17	358.0	179,000	43.77
		ST, 40S	0.375	12.000	14.58	.7854	3.338	3.14	352.5	176,250	49.56
		40	0.406	11.938	15.74	.7773	3.338	3.13	349.0	174,500	53.52
		XS, 80S	0.500	11.750	19.24	.7530	3.338	3.08	338.0	169,000	65.42
		60	0.562	11.626	21.52	.7372	3.338	3.04	331.0	165,500	73.15
		80	0.688	11.374	26.07	.7056	3.338	2.98	316.7	158,350	88.63
		100	0.844	11.062	31.57	.6674	3.338	2.90	299.6	149,800	107.32
		120, XX	1.000	10.750	36.91	.6303	3.338	2.81	283.0	141,500	125.49
		140	1.125	10.500	41.09	.6013	3.338	2.75	270.0	135,000	139.67
		160	1.312	10.126	47.14	.5592	3.338	2.65	251.0	125,500	160.27
14	14	5S	0.156	13.688	6.78	1.0219	3.665	3.58	459	229,500	23.07
		10S	0.188	13.624	8.16	1.0125	3.665	3.57	454	227,000	27.73
		10	0.250	13.500	10.80	0.9940	3.665	3.53	446	223,000	36.71
		20	0.312	13.376	13.42	0.9750	3.665	3.50	438	219,000	45.61
		30, ST	0.375	13.250	16.05	0.9575	3.665	3.47	430	215,000	54.57
		40	0.438	13.124	18.66	0.9397	3.665	3.44	422	211,000	63.44
		XS	0.500	13.000	21.21	0.9218	3.665	3.40	414	207,000	72.09
		60	0.594	12.812	25.02	0.8957	3.665	3.35	402	201,000	85.05
		80	0.750	12.500	31.22	0.8522	3.665	3.27	382	191,000	106.13
		100	0.938	12.124	38.49	0.8017	3.665	3.17	360	180,000	130.85
		120	1.094	11.812	44.36	0.7610	3.665	3.09	342	171,000	150.79
		140	1.250	11.500	50.07	0.7213	3.665	3.01	324	162,000	170.21
		160	1.406	11.188	55.63	0.6827	3.665	2.93	306	153,000	189.11
16	16	5S	0.165	15.670	8.21	1.3393	4.189	4.10	601	300,500	27.90
		10S	0.188	15.624	9.34	1.3314	4.189	4.09	598	299,000	31.75
		10	0.250	15.500	12.37	1.3104	4.189	4.06	587	293,500	42.05
		20	0.312	15.376	15.38	1.2985	4.189	4.03	578	289,000	52.27
		30, ST	0.375	15.250	18.41	1.2680	4.189	3.99	568	284,000	62.58
		40, XS	0.500	15.000	24.35	1.2272	4.189	3.93	550	275,000	82.77
		60	0.656	14.688	31.62	1.1766	4.189	3.85	528	264,000	107.50

Pipe Data: Steel Pipe (cont.)

Nominal Pipe Size, in.	Outside Diameter, in.	Schedule No.	Wall Thickness, in.	Inside Diameter, in.	Cross-sectional Area		Circumference, ft., or surface, ft²/ft of length		Capacity at 1-ft/s velocity		Weight of plain-end pipe, lb/ft
					Metal, in²	Flow, ft²	Outside	Inside	U.S. gal/min	lb/h water	
		80	0.844	14.312	40.19	1.1171	4.189	3.75	501	250,500	136.61
		100	1.031	13.938	48.48	1.0596	4.189	3.65	474	237,000	164.82
		120	1.219	13.562	56.61	1.0032	4.189	3.55	450	225,000	192.43
		140	1.438	13.124	65.79	0.9394	4.189	3.44	422	211,000	223.64
		160	1.594	12.812	72.14	0.8953	4.189	3.35	402	201,000	245.25
18	18	5S	0.165	17.670	9.25	1.7029	4.712	4.63	764	382,000	31.43
		10S	0.188	17.624	10.52	1.6941	4.712	4.51	760	379,400	35.76
		10	0.250	17.500	13.94	1.6703	4.712	4.58	750	375,000	47.39
		20	0.312	17.376	17.34	1.6468	4.712	4.55	739	369,500	58.94
		ST	0.375	17.250	20.76	1.6230	4.712	4.52	728	364,000	70.59
		30	0.438	17.124	24.16	1.5993	4.712	4.48	718	359,000	82.15
		XS	0.500	17.000	27.49	1.5763	4.712	4.45	707	353,500	93.45
		40	0.562	16.876	30.79	1.5533	4.712	4.42	697	348,500	104.67
		60	0.750	16.500	40.64	1.4849	4.712	4.32	666	333,000	138.17
		80	0.938	16.124	50.28	1.4180	4.712	4.22	636	318,000	170.92
		100	1.156	15.688	61.17	1.3423	4.712	4.11	602	301,000	207.96
		120	1.375	15.250	71.82	1.2684	4.712	3.99	569	284,500	244.14
		140	1.562	14.876	80.66	1.2070	4.712	3.89	540	270,000	274.22
		160	1.781	14.438	90.75	1.1370	4.712	3.78	510	255,000	308.50
20	20	5S	0.188	19.624	11.70	2.1004	5.236	5.14	943	471,500	39.78
		10S	0.218	19.564	13.55	2.0878	5.236	5.12	937	467,500	46.06
		10	0.250	19.500	15.51	2.0740	5.236	5.11	930	465,000	52.73
		20, ST	0.375	19.250	23.12	2.0211	5.236	5.04	902	451,000	78.60
		30, XS	0.500	19.000	30.63	1.9689	5.236	4.97	883	441,500	104.13
		40	0.594	18.812	36.21	1.9302	5.236	4.92	866	433,000	123.11
		60	0.812	18.376	48.95	1.8417	5.236	4.81	826	413,000	166.40
		80	1.031	17.938	61.44	1.7550	5.236	4.70	787	393,500	208.87
		100	1.281	17.438	75.33	1.6585	5.236	4.57	744	372,000	256.10
		120	1.500	17.000	87.18	1.5763	5.236	4.45	707	353,500	296.37
		140	1.750	16.500	100.3	1.4849	5.236	4.32	665	332,500	341.09
		160	1.969	16.062	111.5	1.4071	5.236	4.21	632	316,000	397.17
24	24	5S	0.218	23.564	16.29	3.0285	6.283	6.17	1359	679,500	55.37
		10, 10S	0.250	23.500	18.65	3.012	6.283	6.15	1350	675,000	63.41
		20, ST	0.375	23.250	27.83	2.948	6.283	6.09	1325	662,500	94.62
		XS	0.500	23.000	36.90	2.885	6.283	6.02	1295	642,500	125.49
		30	0.562	22.876	41.39	2.854	6.283	5.99	1281	640,500	140.68
		40	0.688	22.624	50.39	2.792	6.283	5.92	1253	626,500	171.29
		60	0.969	22.062	70.11	2.655	6.283	5.78	1192	596,000	238.35
		80	1.219	21.562	87.24	2.536	6.283	5.64	1138	569,000	296.58
		100	1.531	20.938	108.1	2.391	6.283	5.48	1073	536,500	367.39
		120	1.812	20.376	126.3	2.264	6.283	5.33	1016	508,000	429.39
		140	2.062	19.876	142.1	2.155	6.283	5.20	965	482,500	483.12
		160	2.344	19.312	159.5	2.034	6.283	5.06	913	456,500	542.13
30	30	5S	0.250	29.500	23.37	4.746	7.854	7.72	2130	1,065,000	79.43
		10, 10S	0.312	29.376	29.10	4.707	7.854	7.69	2110	1,055,000	98.93
		ST	0.375	29.259	34.90	4.666	7.854	7.66	2094	1,048,000	118.65
		20, XS	0.500	29.000	46.34	4.587	7.854	7.59	2055	1,027,500	157.53
		30	0.625	28.750	57.68	4.508	7.854	7.53	2020	1,010,000	196.08

5S, 10S, and 40S are extracted from Stainless Steel Pipe, ANSI B36.19–1976, the American Society of Mechanical Engineers, New York. ST = standard wall, XS = extra strong wall, XX = double extra strong wall, and Schedules 10 through 160 are extracted from Wrought-Steel and Wrought-Iron Pipe, ANSI B36.10–1975. Decimal thicknesses for respective pipe sizes represent their nominal or average wall dimensions. Mill tolerances as high as ± 12½ percent are permitted.

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