Glass Autoclaves

Bottom heated glass autoclave

Glass-PEEK jacketted autoclave

Interchangeable glass & metal autoclaves

Salient features

- 100 ml to 2 ltr net filling volume
- Pressures upto 10 bar & temperatures upto 200°C
- Glass with metal/PEEK
- Bottom heated, jacketed & triple walled options
- Interchangeable glass & high pressure metal autoclaves
- With suitable safety guard

Standard models for glass autoclaves

Volume	100 ml		500 ml		1 ltr		2 ltr	
Model No.	G 1360	G 1370	G 2160	G 2170	G 2360	G 2370	G 2460	G 2470
Design Pressure	6 bar	10 bar	6 bar	10 bar	6 bar	10 bar	6 bar	10 bar
Design Temperature	150°C (option up to 200°C in Jacketed glass vessel)							
Vessel I/D (mm)	40		75		101.6			
Vessel Internal Height (mm)	83		118		163		303	
Min. Stirrable Volume (ml)	20		60		130			

Note: The above ratings are only for glass material, for other materials the rating will change depending on its stress value & maximum allowable temperature as per ASME code for which refer page 21 in material of construction.

Technical specification for glass autoclaves standard models

Sr.	Description	Specification		
A	Material of Construction	Borosilicate glass cylinder with other wetted parts of SS 316		
B	Head Mounting Style	Removable head and vessel design		
C	Heating Type	Electrical plate heater from bottom (jacket optional)		
D	Motor	1/8 hp AC motor with 100-1450 RPM (100 ml) ¼ hp AC motor with 100-1450 RPM (500 ml to 2 ltr)		
E	Shaft Sealing	Zero leakage magnetic drive coupling M8 with 0.8 Nm torque for 100 ml, Zero leakage magnetic drive coupling M20 with 2 Nm torque for 500 ml to 2 ltr		
F	Stirrer	4 bladed turbine stirrer (100 ml) 2 stage 6 bladed turbine stirrer (500 ml to 2 ltr)		
G	Standard Nozzles, Valves & Fittings	**External Valves & Fittings:** Pressure gauge, safety rupture disc, gas inlet and liquid sampling needle valve with common dip tube, vent needle valve, solenoid valve at inlet of cooling coil (100 ml) **Internal Fittings:** Serpentine cooling coil (100 ml), Helical cooling coil (500 ml to 2 ltr), dip tube, thermowell with RTD PT 100 sensor		
H	Gasket	PTFE		
I	Control Panel	SS control panel with programmable PID temperature controller & high temperature alarm and variable frequency drive for motor speed control		
J	Power Supply	1 Ø, 220 V AC, 50 / 60 Hz		
K	Mounting & Dimensions (W x D x H)	Mounting	Reactor Volume	Dimensions in (mm) without control panel*
		SS Table Top	100ml	300 x 300 x 700
			500 ml	320 x 300 x 700
			1 ltr	380 x 310 x 910
			2 ltr	380 x 310 x 1050
L	Guard	Polycarbonate guard will be provided around glass body		

*For table top models control panel is 275 mm x 275 mm x 300 mm (W x D x H)

2 ltr jacketed glass

Enquiry guide for glass autoclave customized models

Enquiry code structure is **Standard Model no-A-B-C-D1-D2-D3-F-G-I-K-L-M** where A, B, C, D1, D2, D3, F, G, I, J, K, L & M options can be selected from below tables. The below options will be in place of standard supply. For example 1 ltr, 6 bar, 200°C, Hastelloy C, fixed head with pneumatic vessel rasing lowering autoclave, jacketed glass vessel, ¼ hp, ex-proof CE ATEX certified motor, ruston turbine autoclave code will read as **G 2360-HC6-P-EJ-H02-AZ-SR**

Options

A Material of Construction (other wetted parts)

PEEK	PEK	Nickel 200	NK2
Hastelloy C 276	HC6	Titanium Gr. 2	TI2
Hastelloy B	HAB	Zirconium 702	ZR7
Monel 400	MN4	Tantalum	TAN
Inconel 600	IN6	Tantalum lined	TNL

B Head Mounting Style

Fixed head with manual vessel raising lowering (100 ml & 500 ml)	K
Fixed head with manual vessel raising lowering & tilting (500 ml)	KT
Fixed head with pneumatic vessel raising lowering (500 ml to 2 ltr)	P
Fixed head with pneumatic vessel raising lowering & tilting (500 ml to 2 ltr)	PT

C Heating Style*

Jacketed glass vessel (up to 200°C)	EJ
Triple walled double jacket glass vessel for heating & vacuum insulation (up to 200°C)	ET

D1 Motor HP

¼ hp (for 100 ml)	H02
½ hp (for 500 ml to 2 ltr)	H05

D2 Motor RPM

Up to 3000 rpm	RT
Gear box up to 440 rpm	R4

D3 Motor Type

Ex-proof gas group IIB (Zone 1)	XB
Ex-proof gas group IIC (Zone 1)	XC
Ex-proof CE ATEX certified II 2G Ex de IIC T4	AZ
Ex-proof CSA certified Class 1 Div 2 group A, B, C, D	CD
1/8 hp compact in line brushless DC motor	BD
¼ hp compact in line brushless DC motor	QD

F Stirrer Options**

Hollow shaft with gas induction Impeller	SH
Anchor (with serpentine cooling coil, max 100 rpm))	SA
Spiral (no cooling coil, max 100 rpm)	SS
Ruston turbine	SR
Paddle	SD
Propeller	SP

G Valves & Fittings (for 500 ml - 2 ltr)***

Serpentine cooling coil	SCC
Ball valve powder inlet ¼" with funnel	BVP
Flush bottom valve (10 mm)	FBV
Baffles (with serpentine cooling coil)	BFL

I Control Panel

Touch screen	TSP

K Mounting & Overall Dimensions (approx)

Mounting	Autoclave Volume	Autoclave with control panel approx. dia (WxDxH) in mm	Code
Trolley	100 ml	1010 x 410 x 1450	TL
	500 ml	1010 x 410 x 1450	
	1 ltr	1040 x 410 x 1660	
	2 ltr	1040 x 410 x 1800	

L Interchangeable Metal Autoclave

Interchangeable metal vessel of same volume up to 100 bar & 250°C	IM

M Mag Drive Torque

2 Nm (100 ml)	M20
4 Nm (500 ml to 2 ltr)	M40
8 Nm (500 ml to 2 ltr)	M80
12 Nm (1 & 2 ltr)	M120

Note: 1) Customer is advised to select best suited options for most optimized price & delivery.
2) For other optional accessories please refer page 44.
3) All above options may not be available / possible with all models.
4) Customization of volume, material, pressure, temperature etc. may be possible on request.
5) Overall dimensions are indicative, they may change depending on the optional accessories or specific design modifications opted.
*Internal cooling coil & PID temperature controller will be removed for jacketed options.
**Stirrers can be in place of standard or can be offered additionally as interchangeable stirrers.
***All option in G are addons & can be inquired in single enquiry.

Material of Construction (MOC)

All wetted parts are made from SS-316 as standard.

Optional:

SS-316L, Hastelloy B/C, Titanium, Monel, Nickel, Inconel, Zirconium, Tantalum, Carbon Steel etc. for different liquids corrosive to SS-316. Other special alloys like A286, Alloy 20, duplex steel etc. can also be offered.

Note: Amar offers all the internal & optionally external wetted parts in the same material of construction as that of body & head to give fully corrosion resistant autoclaves.

Material Selection Guide

AMAR gives recommendation for material selection for particular media, however it does not guarantee 100% corrosion resistance of a particular material to a particular corrosive media, as the same depends on various parameters like temperature, pressure, concentration etc. of the reactions. Reactor vessels of material SS316, upto 5 ltr are machined from rolled / forged bar stock & reactors above 5 ltr are normally fabricated from plates. SS316 autoclaves upto 100 ltr have lids made from rolled / forged bar stock. The material listed below may not be available in all possible sizes.

General corrosion properties of some metals & alloys* :

RATINGS

0. Unsuitable: Not available in the form required or not suitable for fabrication requirements or not suitable for corrosion conditions.
1. Poor to fair
2. Fair: For mild conditions or when periodic replacement is possible. Restricted use only.
3. Fair to good
4. Good: Suitable when superior alternatives are uneconomical
5. Good to excellent
6. Normally excellent

Small variations in service condition may appreciably affect corrosion. Therefore whenever possible, material choice is guided by a combination of experience and laboratory site tests.

Materials	Non-oxidizing or reducing media				Liquids			Gases			
			Alkaline solutions e.g.		Oxidizing Media			Halogen and derivatives			
								Halogen		Halide acids, moist, e.g. hydrochloric hydrolysis products of organic halides	Hydrogen halides, dry, e.g., dry, Hydrogen chloride
	Acid solutions, excluding hydrochlo-ric, Phos-phoric, sulfuric, (most condition many organics)	Neutral solutions, e.g. many Non-oxidizing salt solutions, chlorides, sulfates	Caustic and mild alkalies, excluding ammonium hydroxide	Ammonium hydroxide and amines	Acid solutions, e.g. nitirc	Neutral or alkaline solutions e.g. per sulfates, peroxides, chromates	Pitting media, acid ferric chloride solutions	Moist, e.g., chlorine below dew point	Dry, e.g. fluorine above dew point		
Stainless Steel, (SS 316)	4	5	5	6	5	6	1	0	3	2	4<220°C 3<400°C
Hastelloy C 276	5	6	5	6	4	6	5	5	4	4	4<400°C 3<480°C
Hastelloy B	6	5	4	4	0	3	0	1	3	5	4<400°C 3<480°C
Inconel 600	3	6	6	6	3	6	1	2	5	3	5<220°C 4<480°C
Monel 400	5	6	6	1	0	5	1	2	6	3	6<220°C 3<400°C 2<480°C
Nickel 200-commercial	4	5	6	1	0	5	0	2	6	2	6<220°C 5<400°C 4<480°C
Titanium	3	6	2	6	6	6	6	6	0	1	0
Zirconium 702	3	6	2	6	6	6	2	6	1	6	0

- The above table is just for reference. Customers are advised to carry out their own tests with sample coupons under desired working conditions.
- From perry, chemical engineer's handbook

Stainless Steel 316/316L

SS316 & 316L have almost identical corrosion resistance properties, only difference being 316L is a low carbon stainless steel.

It has excellent corrosion resistance to

- Most organic acid systems like acetic, formic etc.
- Ammonia & most ammonia compounds
- Many salts except chlorides
- Most commercial gases at moderate temperature & pressures.
- Hydrogen chloride, fluoride & chloride in scrupulously anhydrous systems

It has poor resistance to

- Organic halides
- Dilute sulfuric, phosphoric & nitric acids at high temperatures & pressures.
- Halogen acids at low temperature & in dilute forms
- Caustics, halogen salts, chlorides etc.

Hastelloy C 276 / C22/ C2000

Next most popular after SS316, it is a nickel, chromium, molybdenum alloy that has the widest corrosion resistance & is the most widely used alloy for corrosive media.

It has excellent corrosion resistance to

- Variety of chloride compounds & chlorine contaminated material
- Strong oxidizing chloride solutions such as wet chlorine & hydrochloride & sodium hypochlorite solutions
- Concentrated hydrochloric, sulfuric & phosphoric acids

Depending on the application C276, C22 or C2000 can be selected but C276 is the most common & easily available grade.

Hastelloy B

It is a nickel molybdenum alloy & offers excellent corrosion resistance to solutions of hydrochloric, sulfuric & phosphoric acid in all concentrations & at all temperatures in the absence of oxidizing agents.

Monel 400

It has better resistance than nickel in reducing environments. It has excellent corrosion resistance to

- Caustic solutions
- Chlorinated salts
- Fluorine & hydrogen fluoride

It has poor resistance to nitric acid & ammonia systems.

Inconel 600 / 625

It is a nickel alloy & offers excellent resistance to

- Caustic acids & chlorides at high temperature & pressure when sulfur compounds are present
- Reducing - oxidizing environment
- Sulfur free gases
- Very high temperature

Nickel 200

It offers excellent corrosion resistance to

- Handling concentrated alkalis
- Hot caustic environment
- Chlorinated solvents & Phenol

Titanium Gr 2 / Gr 4

It is lighter material & has excellent corrosion resistance to

- Oxidizing agents such as aqua regia & other mixed acids
- Nitric acid at all concentrations except red fuming nitric acid
- Chloride ions, ferric chloride, cupric chloride & other hot chloride solutions.
- Mild reducing media such as sulfuric & hydrochloric acid
- Titanium burns vigorously in presence of oxygen at high temperatures & pressures.

The material becomes softer above 200°C & hence not advisable above 200°C.

Zirconium

It offers excellent corrosion resistance to

- Reducing environments
- All chlorides except ferric & cupric
- Hydrochloride & sulfuric acids below 70% concentration
- Phosphoric, nitric acids & alkaline solutions

It has poor resistance to oxidizing agents.

Tantalum

Tantalum is practically inert to many oxidizing & reducing acids. It offers the best & most outstanding resistance to wide variety of corrosive media including hydrochloric, nitric, sulfuric & phosphoric acids. It is attacked by hot alkalis & hydrofluoric acid. The costs are prohibitive, however tantalum liner or tantalum lined wetted parts can be offered. Small sizes such as 50 ml - 250 ml can be manufactured completely in Tantalum. The maximum temperatures are restricted to 250°C only.

Chemical composition of different material of construction (major elements in %)

Sr. No.	Material	Fe	Ni	Cr	Mo	C	Other	Max. design temp. in °C
1.	Stainless Steel SS316	60-67	9-12	18-21	2-3	0.08	2.0 Si, 1.5 Mn	600
2.	Hastelloy-C276	4-7	55-63	14.5-16.5	15-17	0.01	Co 2.5, 3-4.5W	600
3.	Hastelloy-B2	2	67-71	1	26-30	0.01	Co 1	427
4.	Monel - 400	2	65	—	—	0.3	2.3 - 3.1 Al, 0.35-0.85 Ti, 30 Cu	482
5.	Inconel - 600	6-10	73-80	14-17	—	0.15	—	600
6.	Inconel - 625	5	58 min	22-23	8-10	0.1	—	650
7.	Nickel - 200	0.4	99.4	—	—	0.15	—	316
8.	Titanium Gr. 2/Gr. 4	99% Pure Titanium				—	—	316
9.	Zirconium 702	95.5 — Zr, 4.5 HF				—	—	371

Autoclave Specifications

Head Mounting Style

Removable head design

This is the most commonly used option & available for all sizes of autoclaves. Here the body rests on the stand / trolley & the head is lifted for charging, discharging & cleaning. The vessel can be removed for charging / discharging / cleaning. This option is more common as the head & vessel can be taken out easily for pressure testing, fitting accessories, servicing etc. The head can be lifted & lowered by chain pulley or hydraulic arrangement on special request for autoclaves above 5 ltr volume.

Optional:

a) Fixed head design with raising & lowering

In this system the head of the autoclave is fixed with motor stand & the vessel & heater are raised & lowered manually by sliding or manually by scissor lift for 50 ml - 250 ml or by rotating screw for 500 ml - 1 ltr or pneumatically / hydraulically. The vessel or heater can be slided manually up & down for assembly or disassembly for 50 ml to 250 ml autoclaves, manually screwed up & down for 500 ml to 1 ltr autoclaves & pneumatic lift is provided for 500 ml to 25 ltr & hydraulic lift for 50 to 100 ltr autoclaves. This system is useful when head of the autoclave has lot of fittings & accessories, making it difficult to lift the head & detach all the fittings after every batch. Further, removing the heater for faster cooling & ease of lifting or lowering the vessel is advantageous.

b) Fixed head design with raising, lowering & tilting

In this system head of the autoclave is fixed while a manual, pneumatic or hydraulic lift allows the vessel (with heater) to be raised & lowered. When lowered the vessel can be tilted. This system is very useful where a vessel needs cleaning after every batch & for highly viscous material to discharge them easily just by tilting.

50 ml & 100 ml interchangeable reactors with fixed head design

750 ml fixed head design with manual screwed vessels raising lowering

2 ltr fixed head with pneumatic vessel lift

2 ltr fixed head with pneumatic raising, lowering & tilting

Heating Types

Electrical ceramic band heater with ceramic wool insulation & cladding.

Optional:

a) Flameproof / explosion proof IIB + H_2 certified, aluminium cast Heater for H_2 gas with totally enclosed heating element inside metal tube. Optionally the heater also has inbuilt cooling coils & is useful when internal cooling coils are not possible / required. These are suitable when the maximum temperature inside the autoclave is less than 300°C. Heating rates are lower in FLP heaters in comparison to ceramic band heaters

b) Sealed heater in SS enclosure with ex-proof group IIC / ATEX zone 1 / class 1 div. 2 certified junction box

c) SS-304 jacket for oil / steam heating with insulation & cladding .

d) If direct electric heating is not permitted (due to spot heating), heater can be provided on jacket with oil inside. The heater can heat the oil which can in turn heat autoclave uniformly.

e) External heater temperature thermocouple is provided with the cascade temperature control to ensure safety of heater, vessel & accurate temperature control. It is a standard feature in aluminum cast heaters.

f) All ceramic band heaters are CE marked.

(a)

(b)

(c)

Autoclave Specifications

Nozzles, Valves & Fittings

Pressure gauge, vent needle valve, safety rupture disc (rated to rupture at MAWP), internal cooling coil, thermowell (with RTD-PT-100 temperature sensor) gas inlet & liquid sampling needle valves with a common dip tube (sparger) upto the bottom.

Optional:

a) **Ball valve with funnel** for powder / slurry / liquid inlet. These valves are 1/4"- 2" size & depending on autoclave volume they can be used to charge solids or liquid slurry at atmospheric pressure or higher, provided a high pressure liquid charging pot is also ordered.

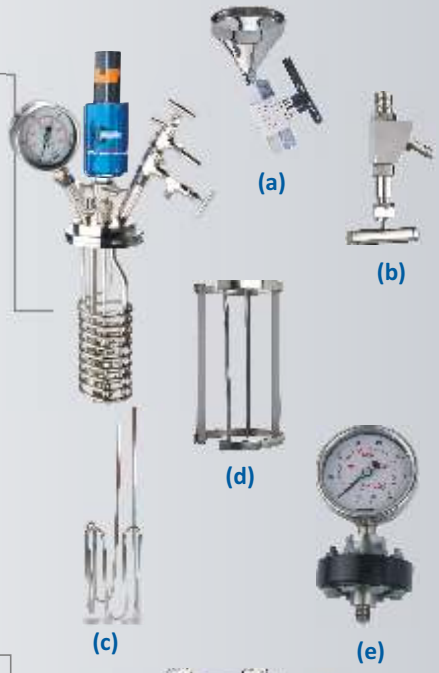
b) **Flush bottom valve** with almost zero dead volume (some times additional ball valve at the outlet of flush bottom valve can be provided on special request).

c) **Serpentine cooling coil** instead of helical for easy cleaning (500 ml to 100 ltr)

d) Removable internal **baffles** for better stirring

e) **Diaphragm pressure gauge:** Teflon coated SS diaphragm, Hastelloy C / Tantalum etc. diaphragm pressure gauge or Monel pressure gauge for corrosive media in non SS autoclaves.

Options (a), (b) & (d) are standard for autoclaves above 5 ltr volume.



Body & Head Sealing

i) Split clamp bolt design:

Split clamp type quick opening system with clamp bolts & tongue & groove sealing with PTFE head gasket for temperatures upto 300°C & metallic grafoil head gasket for temperatures upto 500°C.

ii) Self sealing design:

The head & body can alternatively be sealed by a self sealing design in which there are no clamp bolts. Only the split clamps & FKM (Viton) / FFKM (Kalrez) 'O' ring can be used to give sealing under pressure. The head with 'O' ring is fixed to the body by just sliding the split clamps with latch. This is very easy & convenient for closing & opening the autoclave. However with viton 'O' ring maximum temp. is 225°C & with Kalrez maximum temperature is 275°C. The more expensive Kalrez has better chemical resistance than viton. This sealing can be offered for pressures of 100 bar only. While selecting a viton 'O' ring customers have to check its compatibility with solvents, ammonia etc. as viton gets easily attacked by many of them. This design is available upto 2 ltr only.

iii) Threaded sealing:

For 50 ml - 250 ml vessels there is alternative 'O' ring seal design with threaded clamp & threaded vessel for ease of opening & tightening by hand. This design can be offered for pressures upto 700 bar & temperature upto 225°C for Viton & 275°C for Kalrez 'O' ring.

Motor & Drive

a) Top mounted AC motor

Non flameproof CE marked or Flameproof (FLP)/ Explosion proof AC motor (for Group IIA/ IIB gases) suitable in hazardous area for all flammable liquids / gases except hydrogen & acetylene with variable frequency drive & stirrer RPM indication. The motor is coupled to the magnetic drive directly by specially designed coupling ensuring quick engagement & disengagement of motor from autoclave head. The direct coupling eliminates pulleys, belts & minimizes transmission loses, noise, vibrations & maintenance. The frequency drive can indicate motor current / Torque % (on selection). This is useful to monitor the change in viscosity of the liquid under stirring. The frequency drive is mounted on a common control panel. It has the facility to trip the motor on any overload, over voltage or over current.


Non FLP AC motor


IIA, IIB FLP motor


IIC FLP motor / ATEX motor


Variable speed drive


Motor with gear box

RPM Range: 100 - 1450

Motor Options:

- Flameproof AC motor group IIC, Ideal for H_2 gas
- Ex-proof CE ATEX zone 1 certified
- Ex-proof class 1 div. 2 certified
- Motors with gear box can be offered for stirring highly viscous material at low rpm (50 - 440 rpm)
- Motors with 2900 rpm for stirring at high speeds

b) Compact motor drive:

Compact inline brushless DC motor & magnetic drive & speed controller with indicator for 300-1200 rpm for 50 ml - 25 ltr autoclaves. Very compact, economical & light weight. No external rotating part.


Compact motor drive

Optional Accessories

Optional accessories are offered to increase the versatility of the equipment, to add value & feature to the standard product & to provide complete range of instrument/ equipment required for a particular application. Most of the optional accessories are common for stirred, non-stirred, glass, shaker & fabricated reactors unless specified. The standard optional accessories can be enquired by simply mentioning their code & required specifications.

Complete mounting of all the accessories shall be done on autoclave stand / trolley.

All the indicators / controllers are mounted on a common SS panel.

Gas Pressure Regulator (FPR)

To manually charge different gases at desired pressures upto 140 bar / 2000 psi or higher into the reactor from gas cylinder. Nitrogen, Oxygen & Hydrogen can be charged through same regulator (with special adaptor). The regulator is made from SS316 & comes with inlet - outlet pressure gauges & flexible SS braided Teflon PTFE high pressure hose pipe (4m long) with non return valve.

Optional: 1) Regulators upto 350 bar, automated regulator

2) Regulator for other gases like NH_3, CO_2 etc. & MOC of Hastelloy C

3) Pressure reducing station with auto changeover

Gas Booster (GB)

Gas boosters are useful when the cylinder pressures are much lower than the autoclave rated pressures. In such case the booster takes gas at lower pressure from cylinder & compresses the same to deliver at higher pressures. They are generally pneumatically operated. Special gas booster pumps are available for liquid CO_2 used in supercritical fluid extraction system. The booster systems are supplied with air filter regulator, pressure relief valves, inlet-outlet pressure gauges, valves & flexible hose pipe.

Optional: • Boosters upto 700 bar pressure

Gas Booster

SS mounting with all fittings & valves

Thermal Gas Mass Flow Meter (MFM) / Controller (MFC)

MFM can be used to measure accurate mass flow rate of gas (in gm/hr or LPH) & totalized quantity of mass / volume (in gms/ltr) charged in the autoclave at any point. Mass flow controller (MFC) is used to charge the set flow rate of gas into the autoclave at high pressures up to 100 bar or it can be used in pressure control mode to indicate the gas flow & total gas uptake to maintain desired set pressure inside the autoclave (ideal for hydrogenation). The same MFM / MFC can be used for multiple gases by just entering the conversion factor for different gas densities provided the gases are inert to each other. The MFM/MFC comes with high pressure flexible hose, inlet filter with digital gas flow indicator cum totalizer & additional pressure PID controller with pressure sensor if the MFC is used in pressure control mode. User has to specify the maximum flow rate range, pressure, gas & mode (flow control or pressure control) for ordering MFM/MFC.

Optional: 1) Ex-proof MFM / MFC can be offered on request.

2) MFM/MFC upto 300 bar pressure

MFC

Flow Indicator & Totaliser

Ex-proof MFC

Coriolis Gas - Liquid Mass Flow Meter/Controller (CFM/CFC)

These are used for higher & accurate gas or liquid flow rate indication or control in cases where thermal mass flow meters are not suitable. A common meter can be used for different gases & liquids for a particular range of flow.

Optional: • Ex-proof CFM/CFC can be offered on request

Coriolis Mass Flow Meter

Coriolis Mass Flow Controller

Digital Pressure Indicator / Controller (DPI)

It consists of SS316 pressure sensor (transmitter) & digital pressure indicator/ controller (mounted on common control panel) with pressure alarm & optionally heater cut off for safety. Digital pressure indicator has pressure reading in bar & psi, where as controller reads any one of the units. The controller is normally used with mass flow controllers (MFCs) or solenoid/flow control valves to maintain constant pressure inside the autoclave. With MFC, gas flow indicator & totalizer are also provided on the same panel. The pressure sensor has temperature limitation upto 100°C & hence the same is provided with water cooling jacket.

Optional: 1) Intrinsically safe pressure sensor.

2) Pressure sensors with Hastelloy C / Inconel wetted parts can be offered on request.

Solenoid Valve

Pressure Sensor

Optional Accessories

Liquid / Slurry / Gas Charging High Pressure Pot (HPP)

It is used to transfer liquids, slurries or gases in to the autoclave under pressure. It consists of high pressure SS-316 pot designed for working pressure 100 bar or higher with port for nitrogen gas (N_2), liquid / slurry inlet with valve & funnel, outlet valve, pressure gauge, pressure safety valve, high pressure hose & NRV. The liquid to be charged is fed into the pot from top funnel & pressurized with N_2 gas until its pressure is higher than the autoclave pressure & then under pressure the liquid is charged into the autoclave. The quantity & rate of flow of liquid charged is not known precisely in this system. However a level indicator or sight glass or weighing balance or flow meter can be provided optionally to measure the liquid charged or its flow rate. Pots of different pressure, M.O.C. & sizes can be offered.

These pots can also be used for storage of gases when gas cylinders are located at a far away place. With this option approximate quantity or flow of gas consumed can also be determined by measuring the pressure drop.

Volume: 250 ml, ½ ltr, 1 ltr, 2 ltr, 5 ltr, 10 ltr

Optional: a) Forward pressure regulators can be provided at the outlet of (FPR) pot if they are used as gas charging.

b) Pots upto 200 bar / 350 bar

c) Pots in MOC Hastelloy C, Inconel, Monel, Titanium

Ethylene EO / Polypylene PO Oxide Pot (EPP)

It consists of SS 316 (EO/PO) horizontal pot with inlet, outlet valves, gas inlet with dip tube, thermowell, pressure gauge & high pressure hose pipe for 10 bar working pressure.

It is used for ethoxylation / propoxylation.

Volume: 1 ltr, 2 ltr & 5 ltr

Optional: Ex-proof weighing balance to measure the quantity of EO/PO charged.

Liquid Metering Pump System (LMP)

(b)

(a)

(c)

Weighing Scale

This system is used to charge liquid at a desired rate from as low as 1 ml/hr to 100 ltr/hr, when the autoclave is under pressurized condition. The system comes with a metering pump, flow indicator, controller, liquid sump, pressure gauge, strainer & high pressure hose.

Pressure safety valve, flow totalizer can be offered on request. Types of pumps offered are:

a) Diaphragm metering pumps for pressures upto 100 bar & minimum flow range of 60-600 ml/hr to maximum 10-100 lit/hr. The flow rates are varied by varying the motor speed with variable frequency drive. Materials: SS316, option: Hastelloy C, Titanium, PTFE

b) High pressure more accurate HPLC type low flow metering pumps for high pressures upto 350 bar & flow range from 0.01 upto 100ml/min.

These pumps can be used along with precision weighing scales to measure the total liquid charged at any point of time. Materials: SS316, option: Hastelloy C, Titanium

c) High pressure syringe, PTFE diaphragm, gear, peristaltic pumps can be offered for pumping corrosive chemicals at low / high pressures for specific application & flow rate condition.

In line flow meters can be connected to measure & control the flow of the liquids.

Auto Cooling System (ACV /ACP)

(a) with FLP coil

(b)

This system is useful to control temperature overshoots for highly exothermic / out of control / runaway reactions as well as for faster cooling upon completion of reaction.

The control panel of the autoclave gives 230V, 1Ø output to connect external auto-cooling system. Options available are:

a) Solenoid valve (ACV) for autoclaves upto 25 ltr or

b) Pneumatically actuated ball valves (ACV) for autoclaves above 25 ltr connected at the inlet of the internal cooling coil with external source of water supply.

This is standard for 50 ml - 250 ml autoclaves, however for bigger autoclaves if the cold water line pressure is less than 2 bar then it is better to opt for external pump & tank water cooling system. Normal tap water cooling is not effective at higher temperatures due to steam back pressure whereas pump & tank auto cooling system gives positive pressures & faster cooling.

Optional Accessories

c) Pump & Water Cooling Tank (ACP): It consists of a SS 304 water tank & pump to circulate water in the internal cooling coil of reactors. Cooling starts automatically if the rate of heating rises suddenly. It comes with monoblock pump, tank, pipeline & flexible hose pipes with quick release coupling & is mounted on the autoclave trolley itself. Ice can be put in the water or the hot water can be discharged & fresh water replenished on continuous basis for more effective and faster cooling.

Optional: Ex-proof group IIC pump

(c)

Magnetic drive & pressure Sensor Cooling System (MCS)

It is a simple 10 ltr SS 304 tank with submersible pump to circulate water in the magnetic drive & pressure sensor jacket to prevent temperature rise beyond 80°C. It is useful if tap water connection is not near the autoclave & when water needs to be condensed.

Open Bath Heating Circulator (HB)

It is used to heat jacketed autoclave from ambient to 150°C by circulating thermic fluid inside the jacket. It consist of bath, pump, level switch, heater & internal cooling coil for cooling from high temperature to ambient temperature using chilled water or brine solution.

It is suitable for reactors up to 5 liter volume

Optional: Ex-proof heating bath

Closed Loop Heating Circulator (CLH)

It is used to heat jacketed autoclave from ambient to 350°C by circulating thermic fluid. It consist of a closed pressure withstanding tank, magnetically coupled pump, heater, level indicator & internal cooling coil for cooling from high temperature to ambient temperature using chilled water or brine solution.

Suitable for reactors up to 100 ltr volume

Optional: Ex-proof circulator

Low temperature open bath circulator (CB)

It is used to cool or control reactor temperature to -50°C by circulating thermic fluid cooled to up to -75°C inside the jacket or internal coil. It consists of a bath, pump, compressor, condenser & level switch.

Suitable for reactors up to 100 ltr volume

Heating Cooling open bath circulator (HCB)

It is used to heat, cool & control reactor temperature by circulating thermic fluid in the autoclave jacket. It consists of a bath, pump, heater, compressor, condenser & level switch.

Temperature range: -25°C to 175°C.

Suitable for reactors up to 5 ltr volume

Closed loop heating cooling circulator (CLS)

It is used to heat, cool & control reactor temperature by circulating thermic fluid in the autoclave jacket. It consists of a bath, pump, heater, compressor, condenser & level switch.

Temperature range: -35°C to 200°C / -80°C to 180°C.

Suitable for reactors up to 1000 ltr volume.

Flow Control Valves (FOV / FCV)

These valves can be connected at jacket inlet for controlling flow of steam/ hot oil/ water for temperature control from PID or at the inlet or outlet of the autoclaves for control of pressure.

Two options are available:

- (FOV) On/off pneumatic ball valve actuated by 230V output from panel to solenoid valve inline of air supply
- (FCV) Pneumatic proportionate flow control valves with I to P convertor (for accurate temperature / pressure control).

FOV

FCV

Reflux Condenser (RC)

It is a jacketed single tube SS-316 heat exchanger with packing material inside used to reflux the condensate back into the reactor & vent off the uncondensed vapours. It is connected directly on the autoclave lid & works under full autoclave pressure. A receiver pot can be connected at the bottom of the reflux condenser with valve for reflux take off. It is available in 0.01, 0.02 or 0.05 m^2 area.

Optional: Reflux condensers can be offered in different materials & area.

Optional Accessories

Condenser (CN)

It is a SS-316 shell & tube reverse flow heat exchanger for distillation/condensing vent vapours from the autoclave upto 10 bar pressure. It is offered in different surface areas such as 0.1, 0.2, 0.5, 1 & 2 m^2. The condensate can be collected separately in a receiver or optionally refluxed back into the reactor.

Optional: a) Higher area & pressures upto 350 bar

b) Different materials

c) Corrugated tubes heat exchangers for better efficiency / compact size.

Receiver Pot (RP)

SS 316 receiver pot can be connected at the outlet of the shell & tube or reflux condensor to collect the condensate separately. It is also provided with a port to apply vacuum & offered in 250 ml, 500 ml, 1 ltr, 2 ltr & 5 ltr volumes. Higher volumes & other materials can be offered on special request. It can be optionally provided with level indication.

Back Pressure Regulator (BPR)

It is SS 316 regulator mounted on the vent line of the autoclave & is used for maintaining constant pressure inside the autoclave upto 350 bar. The pressure is maintained by releasing the excess pressure into the atmosphere or through a hose to safe area. The pressure can be set initially on the gauge, by manually varying the knob until the gas comes out. Once the set pressure is exceeded the excess pressure is released until the autoclave pressure becomes equal to or below the set pressure. The pressure release is slow & gradual & the set pressure can be varied at any point.

Optional: a) Electronic actuated digital pneumatic back pressure regulator, where the pressure is set digitally & can be released at preset rate of pressure release (6 bar air supply is required).

b) Pneumatically actuated pilot operated back pressure regulator (air / N_2 gas supply for rated pressure is required to activate the same)

c) Electronic control unit & forward pressure regulator with 4 mtr. hose for activating (b) above.

d) Materials: Hastelloy C, PTFE etc.

Pressure Safety Valve (PSV)

High pressure autoclaves are provided with built in safety rupture disc, however additional safety can be offered by providing pressure safety valve for which release pressure can be set manually by increasing or decreasing the spring tension or by simply changing the spring. The set pressure should normally be around the design pressure. Safety relief valves are standard supply for glass autoclave & shaker hydrogentor where rupture discs are not available for low pressures. These valves come with PTFE / Kalrez O-rings.

Optional: Materials: Hastelloy C, inconel

Chain Pulley / Hydraulic Head Lifting System (PL/EL/HL)

For autoclave volumes from 10 ltr to 250 ltr & removable head design, the head & vessel are too heavy to lift manually. Hence chain pulley block mounted on same trolley with SS Stand can be offered for lifting the head with minimum efforts.

Optional: a) Electric (EL) chain pulley lift

b) Hydraullic lid (HL) lifting arrangement can be offered on request for any reactor volume. Refer page 8 for picture of the same.

SCADA Software for remote operation & recording (SCD)

SCADA is a supervisory control & data acquisition software with all controllers / indicators having RS 485 modbus communication port or PLC & HMI / touch panel, for online display, set point changes & data logging of various parameters like pressure, temperature, motor RPM, motor current / torque, liquid / gas flow rate with totaliser, heater temperature, level, pH, ORP, turbidity, IR etc. remotely from PC as well as locally from panel. It gives continuous online data logging at predefined (variable) time interval, online graphical representation as well as historical data & graphs on PC for single or multiple autoclaves. RS 485-232 convertor & cable upto 50 m or higher is also supplied.

Optional: Wireless data communication from PC to panel or mobile alerts can be supplied on request.

Optional Accessories

Liners (LN)

Removable PTFE / Metal / Glass liners can be offered for autoclaves from 100 ml - 25 ltr. These liners can be used for reactions that are corrosive, to prevent the autoclave body from corrosion. PTFE & glass liners can be used upto 200°C & metal upto 500°C. The heat transfer is poor with PTFE & glass liners. Glass liners cannot be fabricated accurately. Hence, Amar recommends the use of completely corrosion resistant metal autoclaves made from special alloys like Hastelloy, Inconel, Titanium etc. over glass/teflon liners. Liners should be used only if cost is the constraint or corrosive chemicals are to be used sparingly. Metal liners can be offered in Hastelloy C , Inconel , Monel , Titanium etc.

Teflon Metal Glass

Catalyst Basket (CBS/CBD)

It is provided to improve the efficiency of the catalysts & for holding the catalyst so that it will not be destroyed or changed by the stirring action of impeller. The baskets are made from SS316 wire mesh & connected to the stirrer so that they rotate with the stirrer. It is available for 450 ml-100 ltr autoclaves. The catalyst basket can be static which is stationary (CBS) or dynamic (CBD) which rotates with the impeller.

Catalyst Filters (CF)

These are small 7 microns SS 316 sintered cup filters which are threaded to bottom of the sampling dip tube so that the catalyst does not come out while sampling liquid. It is very useful when the catalyst is expensive or pyrophoric. These filters may reduce the rate/ flow of the sampling liquid due to the resistance offered by the fine mesh, hence they need regular cleaning to prevent choking. Filters are available for 500 ml - 100 ltr autoclaves.

Optional: a) Different micron sizes
b) Materials: Hastelloy C

Catalyst Addition Device (CAD)

It is used for one time catalyst charging under pressure during the reaction. It consists of a 3 ml to 150 ml (depending on Autoclave size) small container with airtight cap, which is openable. The powder is filled in the container which is then threaded to the autoclave head from below to a separate port with needle valve on the top. Under atmospheric & pressurized conditions the powder remains inside the container as the cap remains closed.

One has to apply gas pressure greater than autoclave pressure from the needle valve on that port so that the cap opens & releases the catalyst inside the autoclave under pressure.

Depending on the optional accessories selected, the catalyst addition device may not be possible due to space constraint on the head. Available for autoclave sizes 100 ml - 100 ltr & upto 250°C.

Catalyst Filtration & Recycling System (CFR)

It consists of vertical SS sintered filter cartridges in a SS housing. After the batch is over the reactor liquid is transferred to the catalyst filter under reactor/nitrogen pressure. After filtration is over, catalyst is taken back in to the reactor by back washing, thus recycling the same & making it available for the next batch. Thus catalyst is never exposed to atmosphere & is reused. Generally this system is suitable & available for 2 ltr to 2000 ltr reactor volume. These filters are available with zero hold-up volume.

For small autoclaves

Catalyst Slurry Charging System (CSC)

It is a pressure reactor with magnetic drive stirring, inlet & outlet valves, pressure gauge & nitrogen/vent. Solvent & catalyst are charged in the vessel & the slurry formed by mixing is transferred under nitrogen pressure into the reactor. The pressure rating & volume of this system is designed depending on the quantity of catalyst, pressure & temperature rating of the autoclave. Specially designed control system developed by Amar can be offered to charge the catalyst slurry in continuous mode at a pre-defined flow rate under pressure. This is very useful for CSTR, where no suitable pumps are available for slurry. This system is available for any reactor volume, pressures upto 350 bar & for a wide range materials.

Optional Accessories

Catch Pot (CP)

It is used to collect the vent vapours / gases from the autoclave vent / rupture disc / safety valve port, when the vapour / gas is highly hazardous & cannot be released directly into the atmosphere. It is a pressure vessel, designed depending on volume of autoclave & its design pressure. It is provided with inlet, outlet, vent, dip tubes, pressure gauge, safety valve & optionally a flame / flash back arrester. It is normally filled with water. The gases / vapours collected are safely released through the flame / flash back arrester to avoid any hazard. It is suitable & available for any autoclave volume.

Vacuum Pump (VP)

Suitable rotary vane or diaphragm oil fee vacuum pumps can be supplied for vacuum from 100 mbar upto 0.001 mbar in the reactor. It is used either before starting the batch or for high vacuum distillation. Suitable analogue or digital vacuum indicator with controller can be offered on request. The reactor fittings would change for very high vacuum & this may limit its pressure rating

View Windows / Light & Sight Glass (SG)

These are quartz / sapphire view glass windows / light & sight glass of small diameter or along the length of the vessel with special cameras & software for continuous online viewing / recording in jacketed vessels to see the reaction. Suitable for high pressures upto 200 bar & any autoclave / reactor volume.

Multiple view windows

Round view window

Sight glass along the vessel length

In Situ FTIR Spectroscopy (IR)

In situ high temperature, high pressure infrared (IR) probe is offered for real time chemical reaction monitoring. It provides specific information about reaction initiation, conversion, intermediates & end point. Suitable for 1 ltr to 100 ltr reactors upto 100 bar & 200°C.

Other Accessories / Options

a) Level transmitter (LT) / switch (LS) with indicator to measure or maintain level inside the reactor under high pressure. Used mainly in CSTR.

b) pH/ turbidity (TB) / DO / ORP sensors with indicators & controllers for high pressure & temperature application. pH can be controlled automatically by variable speed acid & base metering pumps.

c) Sampling pot with condenser for cooling / condensing & collecting the sample taken at high pressure & temperature.

d) Torque sensor for accurate measurement of the motor torque, where change in torque indicates change in viscosity of the reaction.

e) High pressure ultrasound transducer for high frequency mixing.

f) Ex-proof certified gas purge panels for electrical accessories / utilities like heating cooling circulators etc.

(a)

(b)

(c)

(d)

(e)

(f)

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