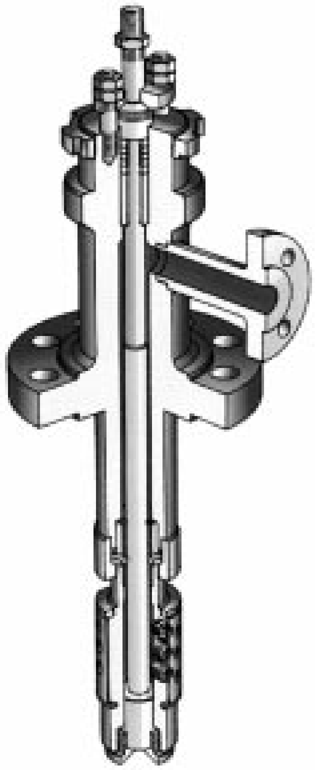
DESUPERHEATING EQUIPMENT AND SYSTEMS



PIPELINE DESUPERHEATERS

- **BV985 - Variable Probe Spray Nozzle**
  - Large range of design Cv options
  - High rangeability
  - Swirl chambers and conical nozzles for optimum atomisation
  - Pipe sizes 150mm (6") and above
  - Interchangeable nozzles
- **BV986 - Fixed Area Spray Ring**
  - Pipe sizes 25mm (1") and above
  - CV designed for each application
  - Simple and inexpensive system
- **BV987 - Desuperheater Pipe**
  - Desuperheater pipe and optional liner
- **BV988 - Fixed Area Probe**
  - Multi nozzle for optimum dispersion in steam flow

COMBINED PRESSURE AND TEMPERATURE REDUCING EQUIPMENT

- **BV994 - Globe Design**
- **BV995 - Angle Design**

These units offer an excellent combination of pressure and temperature control in one cost-effective unit.

Pressure Ratings

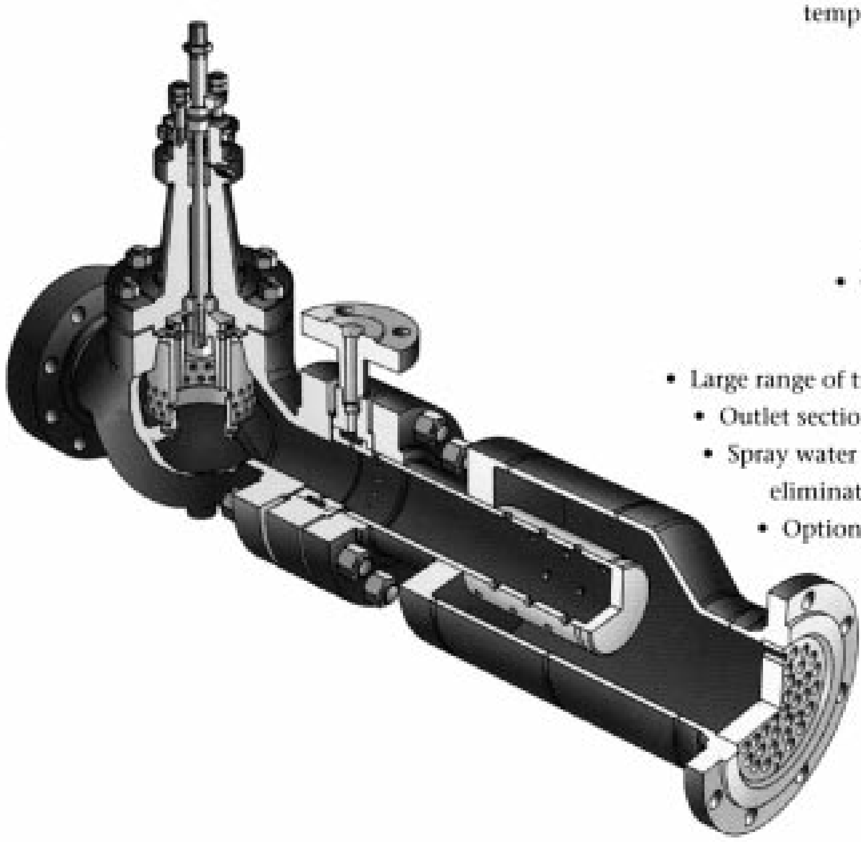
- ANSI Class 150 to ANSI 4500
- PN10 to PN640

Sizes

- Inlet - 40mm (1 1/2") to 500mm (20")
- Outlet - 40mm (1 1/2") to 1000mm (40")

Design Features

- Large range of trim design options - standard to low noise
- Outlet section for improved mixing and noise control
- Spray water injection away from control/seat faces to eliminate problems of thermal shock and erosion
- Optional pilot balanced design for tight shut off
- Proven design



HOPKINSONS
BLAKEBOROUGH
CONTROL VALVES

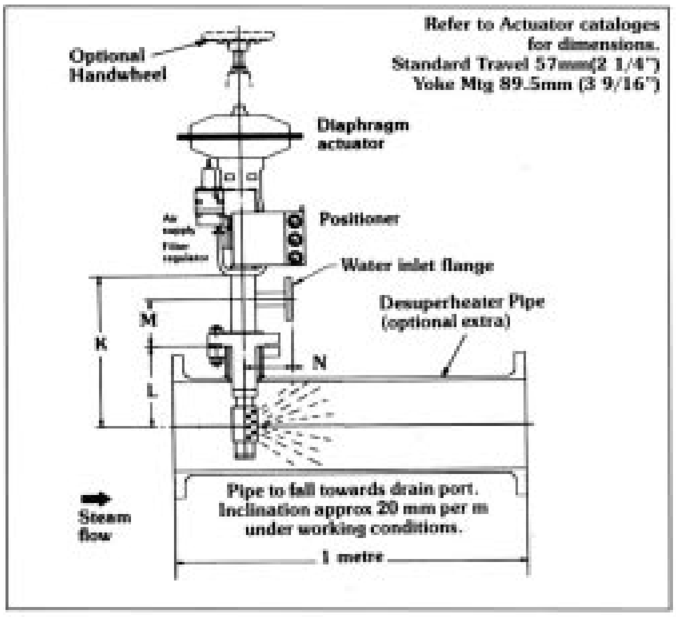
BV985 - VARIABLE SPRAY UNIT

General

The BV985 multi nozzle desuperheater is a proven design used in thousands of installations throughout the world. The latest version offers increased CV ratings and improved rangeability with the option of modified characteristics.

Design Details

- The standard model incorporates 12 carefully spaced spray nozzles for optimum dispersion in the steam flow, and to minimise coalescence of the droplets.
- Nozzles arranged so that at low steam flows water is injected into high turbulence zone of the vortices shed from the desuperheater probe.
- Nozzle design incorporates swirl chambers and conical nozzle for optimum atomisation even at low superior pressures.
- Nozzle assemblies can be characterised to suit process requirements and nozzle selection can be changed after installation.



Standard Design Options

- Water inlet connection size 25mm, 40mm and 50mm (1", 1 1/2" and 2")
- Connection - flanged, socket weld
- Ratings - ANSI 150 to ANSI 2500
- Nozzle sizes (see table 1)
- Superior Pressure 1 bar to 50 bar (15psi to 740psi)
- Nozzle Rangeability - up to 40:1

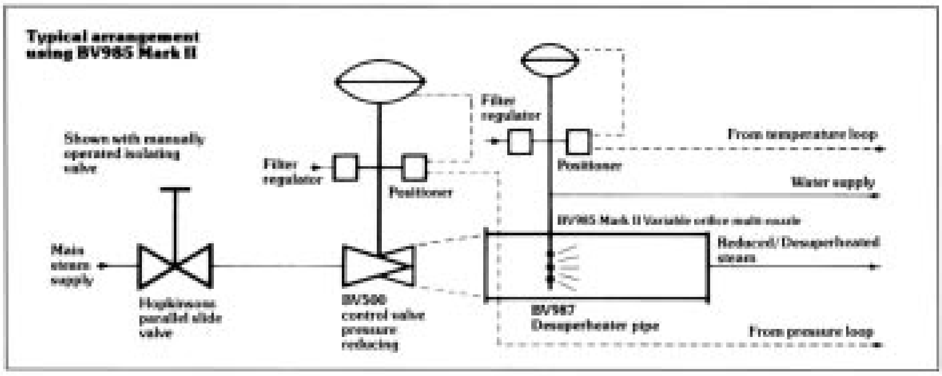
TABLE 1 – NOZZLE DESIGN CV

MN1	MN2	MN3	MN4	MN5	MN6
0.5	0.9	1.5	2.7	4.7	8.0

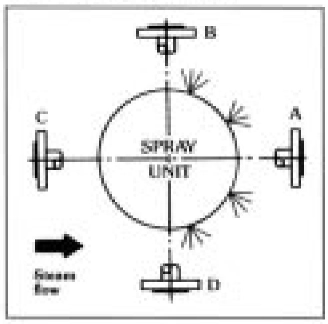
TABLE 2 – BRANCH HEIGHT & ACTUATOR MOUNT DIMENSIONS

BV987 Pipe Size mm	Branch Height L	Act. Mount K
150	177	382
200	200	405
250	226	431
300	251	456
350	277	482
400	302	507
450	327	532
500	350	555
600	372	577
650	416	621
700	454	659
750	480	685
800	501	706
850	517	722
900	547	752

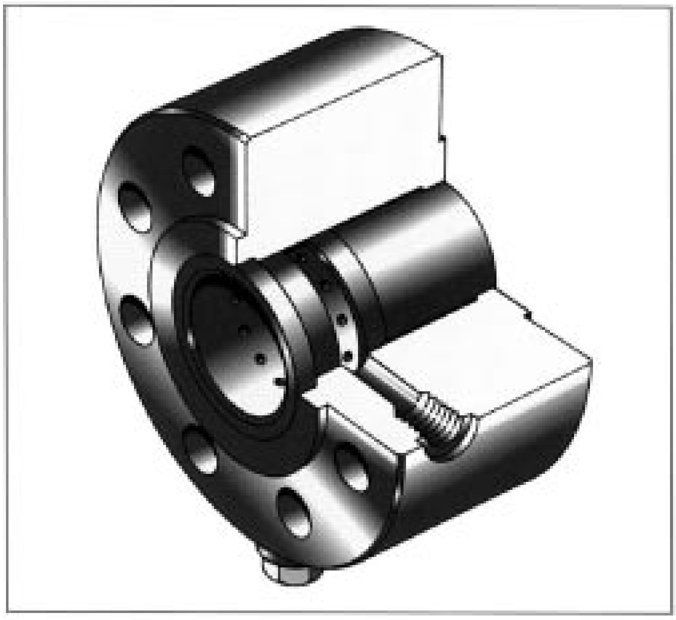
Rating	M	N
≤ 600lb	135	133
900lb & 1500lb	184	167
2500lb	210	200



Water Flange Orientation
The pipework inlet flange can be arranged to suit customer's pipework configurations.



BV986 - FIXED AREA SPRAY RING



General

This unit offers a relatively simple and inexpensive solution for applications which have low rangeability and stable steam demand. The system consists of a spray ring together with a separate spray water control valve. The spray water control valve regulates the flow into an annular feed within the spray ring body. This annular feed passes water into a number of holes to produce a series of radial jets into the steam flow, which assist in the mixing process.

Standard Design Options

- Body size - 25mm to 200mm (1" to 8")
- Ratings - ANSI 150 to ANSI 2500
- Nozzle size designed for specific application
- Superior Pressure 1 bar to 50 bar (15psi to 740psi)
- Rangeability - up to 8:1 on steam flow

FACE TO FACE DIMENSIONS							
Bore (mm)	25	40	50	80	100	150	200
Dimn (mm)	80	80	80	150	150	150	150

DESIGN CV									
MD1	MD2	MD3	MD4	MD5	MD6	MD7	MD8	MD9	MD10
0.03	0.04	0.06	0.1	0.14	0.2	0.4	0.63	1.0	1.4

BV987 - PIPELINE DESUPERHEATER PIPE

The BV987 desuperheater pipe offers a convenient method to install either the BV985 or the BV988. It is available in sizes from 150mm to 900mm (6" to 36"). An 80mm (3") branch flange is provided for mounting the desuperheater. The desuperheater pipe can be supplied in carbon steel or chrome moly. Desuperheater pipes can be supplied with protective liners when the service conditions indicate the possibility of thermal shock or to increase the steam velocity.

TABLE 3 – PIPELINE DESUPERHEATER STANDARD MATERIALS

Component	BV985/BV988	BV986
Body <=427 °C	Carbon Steel	Carbon Steel
Body >427 °C	Chrome Moly	Chrome Moly
Spray unit head	316 L st.st.	
Seat	316 L st.st.	
Plug/Stem	316 L st.st. + stellite face	
Nozzles	316 L st.st.	
Swirl Inserts	316 L st.st.	

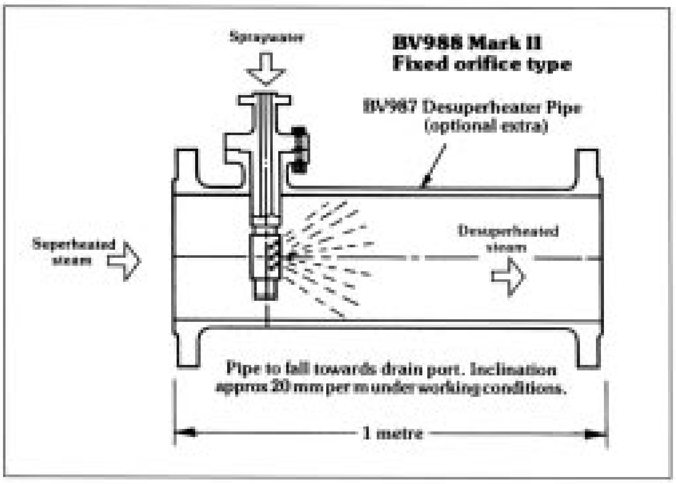
BV988 - FIXED AREA PROBE

General

This multi-nozzle desuperheater can be fitted into line sizes >= 6". The nozzle head is the same as used in the BV985 incorporating up to 12 nozzles. The spray water is regulated by a separate spray water control valve.

Standard Design Options

- Refer to BV985 section
- Rangeability - up to 8:1 on steam flow



HOPKINSONS
BLAKEBOROUGH CONTROL VALVES

COMBINED STEAM REDUCING AND DESUPERHEATING UNIT

BV994 &BV995 UNITS

Application

The BV994 and BV995 range of valves have been designed specifically for the control of process steam to meet the various pressures and temperatures required throughout the plant. It can also be specified to work in parallel with a turbine to supplement the supply of steam to process, also on turbine by-pass duties where the valve dumps the flow directly to the condenser or to cold reheat.

Design

The unit consists of a steam pressure reducing valve, either of angle or globe body configuration, with a specially designed outlet incorporating a spray water injection system and a combined mixer/silencer.

Conditions usually associated with this service are high pressure drop in the critical flow regime leading to sonic conditions across standard trim designs. The BV994 and BV995 units can be fitted with either multiflow or cascade trims. These trims are able to handle the severe service conditions of this application without the by products of vibration, erosion and high noise levels.

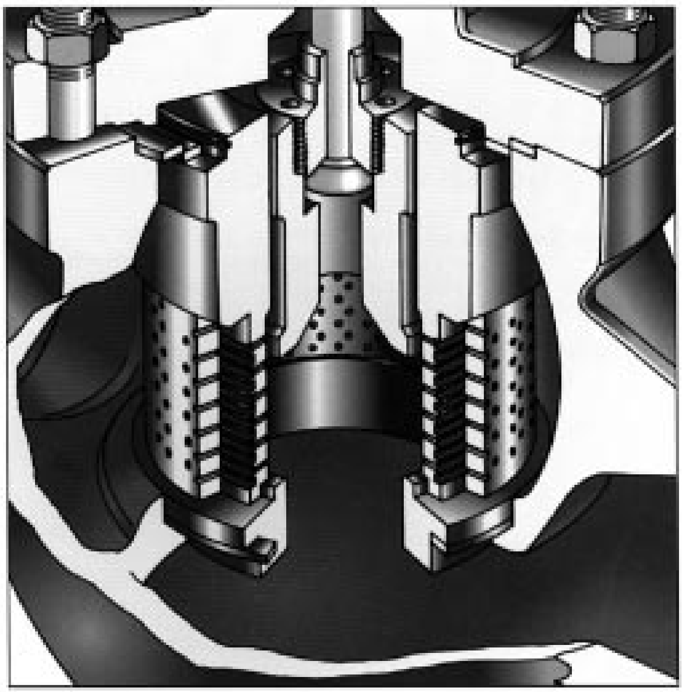
The type of plug generally used in this valve series is a balanced design to reduce the actuator load requirements. This design equalises the pressure above and below the plug in the open position thereby significantly reducing actuator loads. A further advancement on this design is the pilot balanced plug, which enables ANSI Class V shut-off to be achieved without the need of high thrust actuators. This design incorporates two plugs (one within the other), which creates a high integrity sealing system.

The spray system consists of either a spray ring and separate spray water control valve, or a probe type variable spray unit, BV985, depending on steam turn down requirements. The spray water is normally injected before a series of baffle plates, which act to improve desuperheating efficiency. The baffle plates are carefully calculated to produce further stages of pressure drop and improved mixing of the steam and spray water.

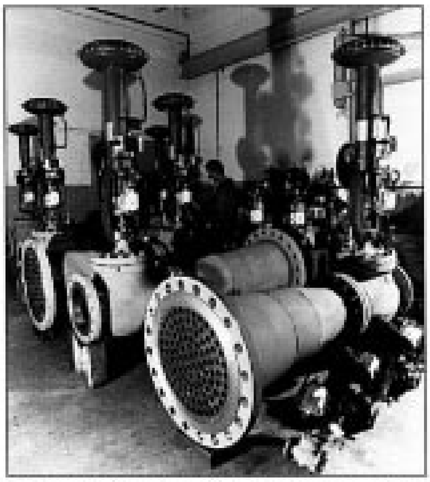
The main steam valve and the spray water valves are commonly fitted with pneumatic diaphragm or piston actuators, fitted with positioners for accurate response.

Standard Design Options

- Pressure Ratings
  ANSI Class 150 to ANSI Class 4500
  PN10 to PN640
- Sizes
  Inlet - 40mm to 500mm (1 1/2" to 20")
  Outlet - 40mm to 1000mm (1 1/2" to 40")
- Trim Options
  Multi-flow, Cascade 2/3/4/5



Pilot Balanced Trim



Valves with low noise trim and outlet silencers destined for a desalination plant in the Middle East.

TURBINE BY-PASS SYSTEMS

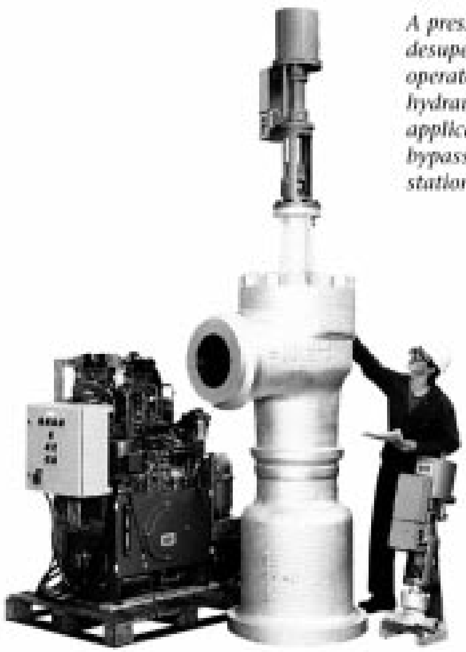
Blakeborough have over 40 years of experience in design and manufacturing valves and desuperheaters. Equipment has been supplied throughout the world ranging from small process applications through to large power generating installations.

Typical Scope of Supply

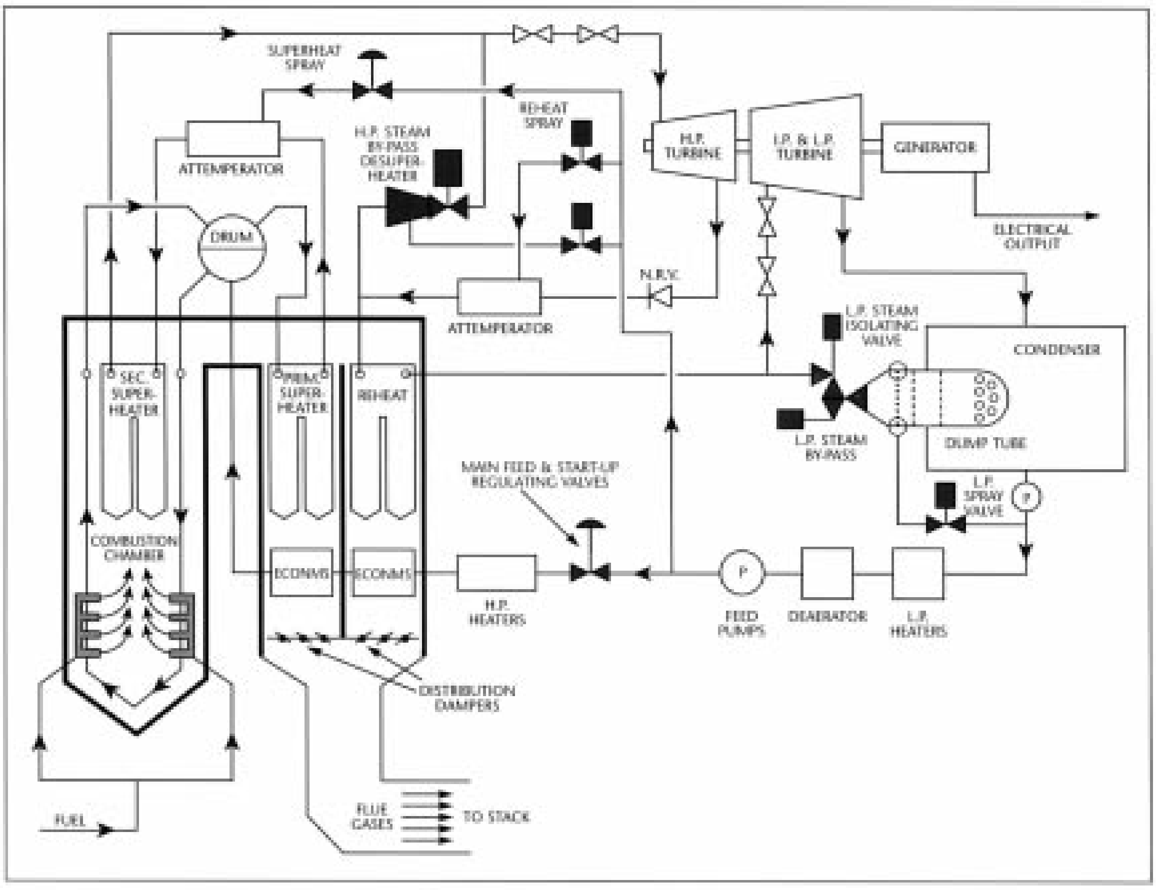
- High pressure by-pass control valve
- High pressure desuperheater
- High pressure spray water control valve
- IP by-pass control valve
- IP desuperheater
- IP spray water control valve
- Low pressure isolation valve
- LP by-pass control valve
- LP desuperheater
- LP spray water control valve

Design Features

- Angle or globe designs.
- Tight shut-off with pilot operation to maximise efficiency.
- Cage guided plugs to eliminate vibration potential.
- Multi-stage low noise trims.
- Erosion resistant trim materials selected which also prevent galling and the effects of thermal cycling.
- Pneumatic or electro-hydraulic actuation.
- Variable spray designs.
- Ancillary instrumentation to give fast response, whilst maintaining stable operation.



A pressure reducing and desuperheating unit operated by electro-hydraulic actuator. The application was turbine bypass on a large power station.



Schematic of Turbine Bypass System

INITIAL SIZING OF DESUPERHEATERS

Information required at enquiry stage

P_1	Inlet Pressure	Bara	(Psia)
T_1	Inlet temperature	°C	(°F)
P_2	Required outlet pressure	Bara	(Psia)
T_2	Required outlet temperature	°C	(°F)
P_W	Available spraywater pressure	Bara	(Psia)
T_W	Spraywater temperature	°C	(°F)
W_S	Maximum inlet steam flow	kg/hr	(lb/hr)
Controlled temp. should be higher than 5 °C (9 °F) above saturation point.			

Initial calculations

Calculate the required flow of water W_W, kg/hr (lb/hr), needed to control the steam temperature at the outlet, by the heat balance method.

$$W_W = \frac{W_S (h_1 - h_2)}{(h_2 - h_F)}$$

where h_1 = enthalpy of superheated steam at inlet
where h_2 = enthalpy of steam mixture at outlet
where h_F = enthalpy of spraywater at inlet
values in kJ/kg (Btu/lb)
Total outlet steam flowrate $W_M = W_S + 2_W$ kg/hr (lb/hr)

Sizing of low pressure pipeline

This is the recommended pipe size for BV985, BV986 and BV988 pipeline types, or the outlet size for the BV995 design for efficient desuperheating.

The pipe is sized so that the steam velocity does not exceed 90m/s (300ft/s) or, for BV985, BV986, BV988 types, fall below 4.5m/s (14ft/s). The preferred velocity is 75m/s (250ft/s).

The minimum pipe diameter is calculated using the following formulae.

$$D = 18.8 \sqrt{\frac{W_M \times V_S}{\text{Velocity}}} \text{ mm or } D = 0.225 \sqrt{\frac{W_M \times V_S}{\text{Velocity}}} \text{ in.}$$

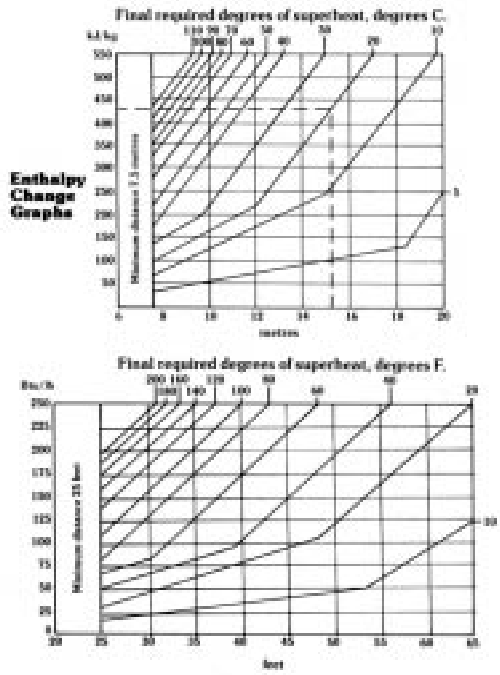
where W_M = outlet steam flowrate	kg/hr	(lb/hr)
where V_S = outlet specific volume	m^3/kg	(ft^3/lb)
Velocity	m/sec	(ft/sec)

- For BV985, BV986 and BV988 desuperheaters there is a selection of standard trim sizes available
- BV995 units are often associated with outlet silencer sections depending upon the ratio of inlet and outlet pressures and the maximum permissible sound pressure. For these reasons each unit receives individual considerations based upon customer requirements.

Distance to temperature sensing point

Depending upon the amount of superheat required in the steam after desuperheating, the minimum recommended distance to the temperature sensing point can be determined from the graphs shown. To ensure complete mixing and absorption of the injected water the recommended distance increases as the steam saturation temperature is approached.

Should the recommended location for the temperature sensing point coincide with a pipe bend, then the sensing point should be moved a further two metres downstream.



Graphs based upon 300mm pipe size. For other sizes multiply distance by $\sqrt{\frac{d}{300}}$ (d = pipe dia. mm)

Examples on use of the above graphs

Steam pressure 10 bara. Saturation temperature 180°C. Required outlet temperature 200°C
Steam Inlet enthalpy 3253kJ/kg, Steam Outlet enthalpy 2829kJ/kg } Enthalpy change 424 kJ/kg
Final required degrees of superheat = 200-180 = 20°C
Draw line from enthalpy change to intercept degrees of superheat line, read off minimum distance = 15.2 metres.

Spraywater Temperature

Effective desuperheater operation depends upon the correct amount of spraywater introduced into the steam flow. If the steam or water temperature conditions dictate a water addition of greater than 20% of the steam mass flow under normal conditions then a two stage nozzle system may be necessary. To limit the amount of water entering the steam to an acceptable level a maximum water temperature can be calculated using the following formulae.

$T_{max} = (P + 0.5D_S - 1.427\Delta h + 630)$	°C Metric
$T_{max} = (0.125P + 0.5D_S - 6.1\Delta h + 1190)$	°F Imperial
where P = absolute steam pressure	bara (psia)
D_S = final required degree of superheat	°C (°F)
Δh = enthalpy change from inlet to outlet	kJ/kg (Btu/lb)

Ideally the water temperature should be within the following range for satisfactory operation:-

$(T_{SAT} - 100)°C < T_{WATER} < (T_{SAT} - 5)$	°C Metric
$(T_{SAT} - 210)°F < T_{WATER} < (T_{SAT} - 10)$	°F Imperial

also applying the maximum water temperature limitations when applicable (T_{SAT} is the stream saturation temperature).

DESIGN AND INSTALLATION OF PIPELINE DESUPERHEATER SYSTEMS

Location in pipework

The desuperheater should be installed so that the spray nozzle is located at the steam inlet of the tube (if supplied). A filter should be fitted in the spray water inlet line to prevent ingress of dirt.

Pipe Joints

Owing to the severe expansion strains which may be imposed on the joints when starting up it is essential that all flange joint bolts are manufactured from high tensile alloy steel irrespective of the steam pressure. These remarks also apply to the water joint flanges which are also subject to sudden temperature changes.

Drainage and drainage systems

Efficient drainage of the pipework following the desuperheater is essential. To ensure that water cannot accumulate at any point the pipe should be arranged to fall in the direction of flow approximately 20mm per metre (1/4" per foot) under actual working conditions and be provided with an efficient large capacity trap (10% of maximum flow to facilitate start-up and shut down of plant) at the lowest point. To prevent the trap becoming airbound the drain pipe should have ample capacity to deal with the drainage and be fixed as near to vertical as possible. There must be sufficient space in the drain pipe for water to flow down and air to pass up the pipe.

When starting up the plant it is advisable to open the trap by-pass valve to deal with any excess water. If a by-pass valve is not fitted the trap should be inspected to ensure that it is passing water and has not become airbound. When the pipework has warmed through to working temperature and a reasonable amount of steam is flowing the drainage of water should practically cease and the trap by-pass valve can then be closed.

Successful operation of a desuperheater depends to a large extent on the injection of water being hot, preferably near to the saturation temperature of the steam to be cooled so that it is mainly the latent heat which is extracted from the steam to evaporate the injected water. This minimises the time of the suspension of the water particles in the steam so that all the water is evaporated and none falls to the inside walls of the pipework. As mentioned below the pipes connecting the water supply to the injection nozzle should be efficiently lagged to minimise the loss of heat.

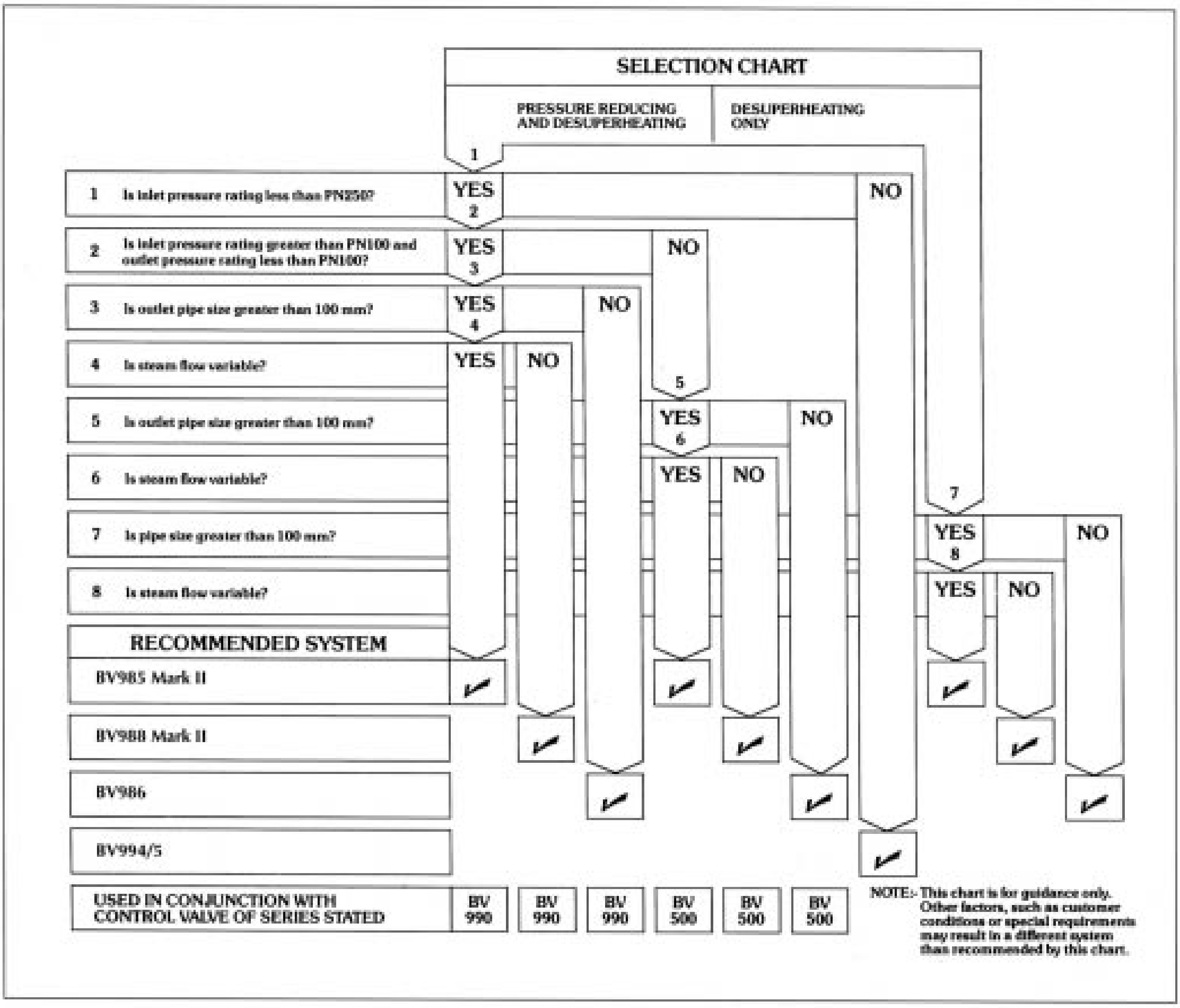
The water pressure and temperature should be no less than the values originally specified at the enquiry/order stage since these figures are used for design purposes in sizing the injection nozzle. The pipes connecting the water supply to the injection nozzle should be no less in diameter than the water isolating valve flange connections indicate.

Condensate supply should be free from debris and effectively filtered to less than 0.25mm.

Lagging of pipes

The fact that a desuperheater is a device for reducing the steam temperature sometimes leads to the mistaken impression that the lagging of steam and water pipes is not important. Unlike the absorption of heat by the spray water, any loss of heat should be avoided. Unless the pipework can be maintained at the proper temperature successful desuperheating may not be possible and a preliminary trial of a plant before it has been lagged may prove disappointing.

DESIGN AND INSTALLATION OF PIPELINE DESUPERHEATER SYSTEMS



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