

ExxonMobil DESIGN PRACTICES	COMPRESSOR COMPRESSOR UNIT PIPING AND PROCESS TRAIN EQUIPMENT PROPRIETARY INFORMATION - For Authorized Company Use Only	Section	Page
		XI-O	1 of 10
		December, 2002	

Changes shown by ↕

CONTENTS

Section	Page
SCOPE	2
REFERENCES	2
DESIGN PRACTICES	2
GLOBAL PRACTICES.....	2
OTHER REFERENCES	2
BACKGROUND.....	2
BASIC DESIGN CONSIDERATIONS.....	2
COMPRESSOR PIPING AND VALVING	2
Sizing Compressor and Steam Turbine Lines	2
Check Valves	4
PROCESS TRAIN EQUIPMENT	5
Compressor Flushing Systems.....	7
Steam Turbine Condensers.....	7
Steam Turbine Washing	8
FIGURE	
Figure 1 Schematic of Typical Steam Turbine Exhaust Condensor System.....	10

Revision Memo

12/02	Page 3 -- Basis discussion revised to Recommend Noise Abatement Insulation on compressors greater than 1000HP
	Page 4 -- Liquid Removal at Low Points discussion revised
	Designing Compressor Piping Connections for Smooth Flow discussion revised
	High Flow Rate Recycle Lines discussion revised
	Page 5 -- Check Valves- location discussion revised
	Page 6 -- Centrifugal Air Compressor filter requirements revised
	Page 11 Figure 1 Added flow meter in condensate line



Section	Page	<i>COMPRESSORS</i> COMPRESSOR UNIT PIPING AND PROCESS TRAIN EQUIPMENT	
XI-O	2 of 10		
December, 2002		PROPRIETARY INFORMATION - For Authorized Company Use Only	DESIGN PRACTICES

SCOPE

This section applies to the basic design of piping systems associated with compressors and their drive systems, and to equipment and facilities in the process train which are directly related to the compressor and driver. Some of the installation facilities, which are unique to one type of compressor or driver only, are covered in the section devoted to that machine type.

REFERENCES

DESIGN PRACTICES

- [Section V](#) [Drums](#)
- [Section XIV](#) [Fluid Flow](#)
- [Section XV-G](#) [Equipment Spacing](#)
- [Section XVIII-C](#) [Guidelines and Considerations for Noise Control](#)

GLOBAL PRACTICES

- GP 3-3-3, Flushing and Drain Piping for Centrifugal and Rotary Gas Compressors
- GP 3-3-5, Suction, Discharge and Interstage Piping for Reciprocating Compressors
- GP 3-3-8, Washing Systems for Steam Turbines
- GP-3-3-10, Strainers for Mechanical Equipment
- GP 3-6-4, Vents and Drains, Flushing and Cleaning Connections
- GP 3-7-1, Piping Flexibility and Supports
- GP 3-12-1, Valve Selection Criteria
- GP 10-13-1, Special Purpose Centrifugal Fans
- GP 14-1-1, Hot Thermal Insulation
- GP 14-2-1, Cold Service Thermal Insulation Design, Materials and Application

OTHER REFERENCES

- API 618, *Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services*.
- Heat Exchange Institute Standard (Standard for Steam Surface Condensers).
- Nathanson, S. L., *Control of Centrifugal Compressor Fouling in Steam Cracker Cracked Gas Service*, EE Report EE.2ER.71.

BACKGROUND

Design of the compression service piping and process train equipment items is just as critical to the successful fulfillment of a compression service as is the selection of the compressor performance conditions. However, design of the piping and equipment items does not require as much design phase effort because most of the design details are covered by Global Practices and developed during the detail engineering phase.

BASIC DESIGN CONSIDERATIONS

COMPRESSOR PIPING AND VALVING

Sizing Compressor and Steam Turbine Lines

- **Basis** - The primary criterion for sizing inlet and discharge piping for all types of compressors and steam turbines is economic, i.e., to achieve minimum annual total (operating and ownership) costs and maximum return on equipment investment. This is done by balancing the investment in piping against the compression machinery and utility facilities costs, and the operating cost of powering the compressor. Guidelines can be used to short cut the economic evaluation process in routine line sizing practice, but individual case analysis is necessary for high investment situations.

 DESIGN PRACTICES	COMPRESSOR		Section	Page
	COMPRESSOR UNIT PIPING AND PROCESS TRAIN EQUIPMENT		XI-O	3 of 10
	PROPRIETARY INFORMATION - For Authorized Company Use Only		December, 2002	

During detail engineering, the piping systems for reciprocating compressors are usually given an acoustic simulation study. This may result in changes to the economic line sizes chosen during the design phase. Line size changes which may be required to reduce pressure pulsation levels to satisfactory values can not be foreseen during the design phase and must be left to the detail engineering phase. See [Section XI-H, Pulsation and Vibration Control](#), for further information.

Noise generation along the pipe wall due to gas velocity is not a significant line sizing consideration since the velocities resulting from economic line size selection generate very little noise in comparison to that generated within the machinery, by recycle control valves and by other flow restrictions. Most piping in the vicinity of steam turbines, and centrifugal and rotary compressors depends upon insulation to attenuate compressor generated noise. On Centrifugal and Axial compressors greater than 1000 horsepower, discharge piping should be considered for noise abatement insulation if in a noise containment area.

- **Economic Evaluation** - Procedures for economic optimization of line size are detailed in [Section XIV, Fluid Flow](#).
- **Sizing Compressor Nozzles** - Compressor nozzle size is selected by the compressor vendor to limit flange-to-rotor pressure losses and to insure smooth flow distribution into and from the moving parts. Vendors normally limit centrifugal compressor nozzle velocity to 125 to 150 ft/sec (35 to 45 m/s), or slightly lower for high molecular weight gases. High-pressure helical screw compressor nozzles are nominally limited to the 55 to 75 ft/sec (15 to 25 m/s) level, because of the pulsating flow characteristic in the nozzles.

Piping Arrangements - Physical arrangement and mechanical design of the piping system associated with compression services are performed during project detail engineering. The considerations in piping arrangement of greatest interest to compression service designers are given in the following paragraphs:

- **Access for Compressor Maintenance**
 - Piping to connections in the top half of horizontally split casings must be flanged close to the compressor to permit removal of the top half of the compressor casing.
 - Overhead piping must be routed to minimize interferences with crane lifts.
 - See also [Section XI-P, Foundations](#).
- **Assurance of Line Cleanliness**
 - Inlet piping should be designed to be as cleanable and inspectable as possible between the inlet separator drum and the compressor inlet flange by using a minimum number of elbows and providing flanging or blanked access stubs in runs which would be otherwise inaccessible.
 - Provision must be made for insertion and removal of temporary strainers close to the compressor inlet, without upsetting compressor alignment. Flanges must sometimes be provided for this purpose alone. See **GP 3-3-10** for strainer requirements.
 - Any recycle lines which connect to the line between the inlet separator drum and the compressor must be arranged for cleaning access, like the main inlet pipe.
- **Minimum Loading of Compressor Flanges**
 - Piping supports must be designed to keep the forces and moments imposed on the compressor flanges by the process piping to levels so low that delicate coupling alignments will not be disturbed as the piping cycles between ambient and operating temperature.
 - To reduce the effects of piping thermal expansion or contraction on compressor flange loading, anchors or expansion "stops" are needed near the compressor flanges.
 - Special means of reducing the frictional drag on pipe supports (plastic slides, line contact bars) are used to minimize and normalize the pipe loadings during the warmup and cooldown periods.
- **Liquid Removal at Low Points** - Low points in compressor inlet piping, while usually necessary, should be minimized to avoid points for liquid collection. Low points drains on compressors in hydrocarbon service should be piped to the appropriate vent and drain systems. See [Liquid in Gas Streams, Section XI-A](#).
- **Designing Compressor Piping Connections for Smooth Flow** - Straight runs of compressor flange size piping are required adjoining the inlet and discharge flanges of centrifugal and axial compressors for the purposes of:
 - Insuring uniform flow distribution as the gas enters the machine inlet volute, so that required machine capacity and efficiency can be achieved.
 - Insuring smooth diffusion (conversion of velocity head to pressure head) as the gas enters the discharge piping, so that turbulence does not cause abnormal pressure drop in the transition zone.
 - Allowing accurate measurements of pressure and temperature for compressor performance testing purposes.

For services where the main line size equals or exceeds the flange size of the selected compressor, the straight run should be at about 3 times nominal compressor flange size in length. For services where the flange size exceeds the line size, the conservatively straight run should be approximately 3 times line size in length. The 3 times rule applies to compressor designed with nozzle velocities above 100 ft/sec (30 m/s). For compressor units so large that the line size