

 DESIGN PRACTICES	PUMPS INSTALLATION FACILITIES	Section	Page
		X-H	1 of 14
		December, 2000	

Changes shown by ↗

CONTENTS

Section	Page
SCOPE	3
REFERENCES	3
LIST OF GII AND DESIGN SPECIFICATION TOPICS	3
GENERAL INSTRUCTION AND INFORMATION ITEMS	3
DESIGN SPECIFICATION ITEMS	3
INSTALLATION FACILITIES FOR SPECIFIC PUMP SYSTEMS/CONDITIONS	4
DESIGNING FOR PARALLEL OPERATION OF PUMPS	4
Reasons for Continuous Parallel Operation	4
Pump Design Features	4
Installation Features and Considerations	5
DESIGNING FOR SERIES OPERATION OF PUMPS	5
Reasons for Series Operation	5
Disadvantages of Series Operation	6
Installation and Design Features for Series Operation	6
DESIGNING FOR LOW FLOW OPERATION OF CENTRIFUGAL PUMPS	6
Determining the Need for a Recycle System	6
Types of Recycle Systems	7
Required Recycle System Features	7
AUTOMATIC START UP OF STANDBY PUMPS	7
Determining the Need for Automatic Starting	7
Parameters Triggering Auto Start	8
Auto Start Control System	8
Steam Turbine Arrangements for Auto Start Service	8
Boiler/Furnace Fuel Oil Service	9
PIPING DESIGN	9
General Considerations	9
Overpressure Protection	9
Warm Up Facilities	9
Casing Vent, Drain and Clean Out Systems	9
Additional Requirements for Cold Service Pumps	10
Pump Suction Strainers	11
Reciprocating Pump Pulsation Considerations	11
WEAR RING FLUSHING	12
VIBRATION AND OTHER MONITORING SYSTEMS	12
OIL MIST LUBRICATION SYSTEMS	12
SEALLESS PUMPS	12
NOMENCLATURE	12

**Documents**

Document Sharing Hub

Section X-H	Page 2 of 14	<i>PUMPS</i> INSTALLATION FACILITIES	ExxonMobil DESIGN PRACTICES
December, 2000			

CONTENTS (Cont)

Section		Page
FIGURES		
Figure 1	Characteristic Curves For Pumps Operating In Parallel.....	13
Figure 2	Suction Line Rise Over Obstruction	14

Revision Memo

12/00	Updated References to current IP revisions and added Oil Mist, Design Specification Items, changed subambient temperature to high pour point, Pump Design Features add limits or tolerances of IP 10-1-1, Series operation added control valve possibility, added VFD and consideration of start-up conditions to recycle systems, Auto Start added information on delta from auto start to shutdown, Casing Vents added check of piping for EBV, updated wear ring flush section.
-------	--

 DESIGN PRACTICES	PUMPS INSTALLATION FACILITIES	Section	Page
		X-H	3 of 14
		December, 2000	

SCOPE

This section provides the installation features needed to integrate individual pumps into operable pumping systems and installations. Most commonly applied situations are mentioned and many unusual services are also mentioned. The reader should be familiar with [IP 3-3-2](#), *Suction and Discharge Piping for Centrifugal Pumps*, which is a primary reference for pump installations.

REFERENCES

DESIGN PRACTICES (BESIDES SECTIONS OF [SECTION X](#))

Section XV	Safety in Plant Design
Section XIV	Fluid Flow
Section XVIII	Air Pollution Control, Industrial Hygiene and Noise Control

OFFSITES DESIGN PRACTICE

Section XXVI-B	Steam Generation Systems
--------------------------------	--------------------------

INTERNATIONAL PRACTICES

IP 3-3-2	Suction and Discharge Piping for Centrifugal Pumps
IP 3-3-7	Inlet and Exhaust Piping for Steam Turbines
IP 3-3-10	Strainers for Mechanical Equipment
♦ IP 3-3-12	Oil Mist Lubrication Systems
IP 3-6-4	Vents and Drains, Flushing and Cleaning Connections
IP 10-1-1	Centrifugal Pumps
IP 10-11-1	Sizing of Drivers and Transmissions for Compressors, Fans and Pumps.
♦ IP 14-1-1	External Insulation
♦ IP 18-10-1	Additional Requirements for Materials

OTHER LITERATURE

API 614	Lubrication, Shaft Sealing and Control Oil Systems and Auxiliaries for Petroleum, Chemical and Gas Industry Services.
API 610	Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Applications
<i>The Pump Sealing Technology Manual</i> , EMRE Manual No. TMEE-23	
<i>The Machinery Design Appraisal Manual</i> , EMRE Manual No. EETD-024	

LIST OF GII AND DESIGN SPECIFICATION TOPICS

This section presents a listing of topics that must be addressed either in the General Instructions and Information or the Design Specification. These topics are addressed in detail later in this section.

GENERAL INSTRUCTION AND INFORMATION ITEMS

- Vibration and temperature monitoring.
- ♦ • Oil mist lubrication systems
- Sealless pump requirements.

DESIGN SPECIFICATION ITEMS

- Installation features for pumps normally running in parallel.
- Installation features for pumps normally running in series.
- Requirements for recycle system installation and control.
- Automatic start up control features.
- Automatically started steam turbine requirements.

Section X-H	Page 4 of 14	<i>PUMPS</i> INSTALLATION FACILITIES	 DESIGN PRACTICES
December, 2000			

LIST OF GII AND DESIGN SPECIFICATION TOPICS (Cont)

- Piping requirements:
 - Overpressure protection.
 - Warm up facilities.
 - Casing vents, drains, clean out and closed drain requirements.
 - Additional requirements for high pour point and cold pumping services.
 - Permanent strainer requirement.
 - Reciprocating pump pulsation control.

INSTALLATION FACILITIES FOR SPECIFIC PUMP SYSTEMS/CONDITIONS

DESIGNING FOR PARALLEL OPERATION OF PUMPS

Reasons for Continuous Parallel Operation

A pumping system may be designed for continuous parallel operation of two or more pumps for several reasons including:

1. Very high reliability is required for the service (such as cooling water, boiler feed water or a furnace feed service) without the reliance on automatic start systems. Shut down of one pump when two or more are operating does not cause complete loss of the service.
2. The service entails very high capacity (again cooling water is an example) which would make single pumps too large or require too much NPSH.
3. Use of single pumps would require drivers which exceed the available utility supply such as motors requiring a voltage that is not available.
4. A desire for operating flexibility and load balancing of energy sources may lead to multiple pumps with different driver types.
5. Use of multiple pumps may allow investment savings. Three 50% pumps may be less expensive than two 100% pumps.
6. A capacity increase is desired on an occasional basis and the decision is made to operate the main and spare pump together rather than install more pumps.
7. A capacity increase is needed in an existing service and another pump is added in parallel.
8. National or local codes require pumps be operated in parallel to increase safety or reliability.

Pump Design Features

In order to provide satisfactory parallel operation the pump curves should match as closely as possible. **Figure 1** demonstrates what may happen when pumps are not acceptable for operation in parallel. The following pump curve features are particularly important and have mandatory limits or tolerances per [IP 10-1-1, Centrifugal Pumps](#):

1. Shutoff head for both pumps should be equal.
2. The head curve must not "droop" as the flow decreases toward zero to avoid potentially unstable operation from two flow rates having the same head rise.
3. The curves should have close similarity of shape to insure proper load sharing.
4. The head at shutoff should be at least 110% of the head at BEP to avoid a flat characteristic with large flow rate changes with only a slight head change.

MACHINERY SPECIALISTS should always be consulted when continuous parallel operation is planned to determine any additional requirements based on the anticipated pump types used. However, the degree of care required during Design Specification preparation and Detail Design depends strongly on how similar or dissimilar the pumps to be paralleled are. The simplest and most common situation is paralleling two identical pumps with identical driver types. The following situations make parallel pump operation increasingly difficult.

1. Identical pumps with different driver types, especially variable speed drives (turbines or motors).
2. Similar pump types but with different head / capacity characteristics or best efficiency point.
3. Centrifugal pumps with drooping head curves such as high-speed pumps (which are permitted per [IP 10-1-1](#)). Limit the low flow operation to at least 115% of the flow corresponding to the shut off head but to the right of the maximum head.
4. Parallel operation of centrifugal pumps with positive displacement pumps.

 DESIGN PRACTICES	PUMPS INSTALLATION FACILITIES	Section	Page
		X-H	5 of 14
		December, 2000	

INSTALLATION FACILITIES FOR SPECIFIC PUMP SYSTEMS/CONDITIONS (Cont)

Installation Features and Considerations

The following installation details should be considered and added to the Design Specification pump data sheet or Section 300 as appropriate for the specific pump service if continuous parallel operation is the basis for the design.

- When installing multiple pumps for high reliability, ensure that the required flow can be met during any single contingency utility outage. For example, in cooling water systems there will be a minimum required flow in the event of an electrical power outage. Ensure that the number of pumps and types of drivers selected can accommodate this minimum flow.
- When calculating utility requirements, ensure that the drivers are sized for end of curve operation per [IP 10-11-1, Sizing of Drivers and Transmissions for Compressors, Fans and Pumps](#). This will help ensure that if one pump carries more load than another it will have sufficient power. It also prevents a pump from tripping on overload should a parallel pump suddenly shut down.
- Automatic start up systems, when applied to parallel pumps, should be designed to allow any of the parallel pumps to be automatically started. See the paragraphs in this section under the heading AUTOMATIC START UP OF STANDBY PUMPS.
- Instrumentation and control systems for pumps to be operated in parallel are critical for ensuring proper load sharing and troubleshooting. The following features should be considered and added when appropriate:
 - Location in the discharge of each pump for installation of a flow measuring orifice.
 - A power meter located in the substation for motor drivers.
 - A steam flow meter for steam turbine drivers.
 - Pump mounted tachometer for variable speed drivers (turbine or motor).
- Ensure that NPSH_{available} calculations are based on running the highest number of pumps anticipated. Also ensure that the suction line is as symmetrical as possible with respect to all the pumps to avoid NPSH insufficiency on any particular pump.
- Where two or more pumps are normally operated in parallel but where the flow rate is likely to fall to a rate requiring only one pump, install recycle systems and/or low flow alarms to indicate when one pump should be shut down.
- Consider installing continuous vibration monitoring and/or bearing temperature detectors, especially if the pumps are large and expensive to repair or the service is critical. For large motors, also consider RF (Radio Frequency monitoring, consult ELECTRICAL SPECIALISTS) monitoring. The use of monitoring equipment can often avoid failures which result from one pump shutting off another and the problems of increased vibration which occur as pumps are forced back on their curve.

DESIGNING FOR SERIES OPERATION OF PUMPS

Reasons for Series Operation

There are a few instances where pumps operating in series may be required. These include:

- Operation of pumps in series may be needed when one pump has an unusually high NPSH requirement. This is often the case for large, reciprocating power pumps where it is common to find an upstream centrifugal booster pump.
- The required differential pressure changes due to specific operations or over time such that a single pump is not capable of providing the required pressure at all times. Series operation may also be desired from a flexibility standpoint. Having multiple pumps and providing the means to operate them singly, in parallel or in series is a common practice for producing and pipeline applications.
- Feed or product streams from tankage must be transported to the process unit where another pump provides the pressure needed for the unit operation. This is a common practice but because the pumps are so far apart, it is not usually thought of as operating pumps in series.
- High concentration slurry services often necessitate using pumps in series. Solids tend to quickly erode the inter-stage bushings of multistage pumps making them inappropriate for slurry service. Slow speeds and pumps in series are then used.
- In some cases, overall equipment cost reduction can be achieved. Using a crude feed system as an example, it is more cost effective to install booster pumps downstream of the desalters to run in series with the upstream pumps since this lowers the desalter design pressure.