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Valves



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3 Scope

There are four basic functions of valves as used in the oil, gas and petrochemicals industry:

- To start and stop flow;
- To control flow or pressure;
- To prevent back-flow; and
- To relieve excess pressure or vacuum.

Gate valves are particularly useful for starting and stopping the flow of fluids. Control valves are especially useful for controlling fluid or gas pressure. Check valves are uniquely designed to prevent back-flow. Relief valves are uniquely designed to relieve excess pressure. Globe valves can do any of the above, but are particularly suited to start/stop and flow regulation.

This study focuses on Gate, Globe, Relief, and Control valves as they are used in the energy industry, with particular focus on oil and gas. We look at the broader energy industry because there is technology crossover and products sometimes apply to the power and fuels industries, and the economics can be similar because the various energy industries require valves as a critical process control element, as opposed to general industry, where they are often a support or MRO item.

Gate valves are designed to minimize pressure loss because they can operate fully open or fully closed. Their purpose is to cut off flow when desired, usually through use of a shut-off plate or wedge. The scope includes all types of Gate vales, including:

- 'Knife' type, which is especially used to control the flow of heavy oil.
- Parallel wedge valve is characterized by having parallel valve seats. It is the most-used type of Gate valve in oil & gas applications.
- Wedge Gate Valve is used to a much lesser extent in oil & gas. There are three types of wedge gates: solid, flexible and split.

Gate valves are frequently used in midstream (pipeline) applications where they can be either fully shut off or open full throttle. Here they can be called an isolation valve if their purpose is to isolate liquid from a zone in the pipe. Gate valves also have upstream and downstream applications, for example upstream they can be used in the drilling standpipe manifold, pump manifold block valves, mud mixing lines, drilling system flow control, wellheads, and in production manifolds, gathering systems, and flow lines. Downstream Gate valves can be combined with special sealing and even leak detection in refinery applications, such as in a hydrofluoric alkylation unit. The Gate valve scope used in this report includes the manufacture of all materials and pressure classes, including electrically actuated.

Globe valves are used to regulate flow through use of a ball, which is housed in a bonnet and positioned with a seat ring, to constrict flow. Their design allows them to be used for relatively accurate proportioning of flow. Because they are relatively simple, they are generally strong, rugged, and reliable, and hence are used everywhere in the hydrocarbon value chain, especially upstream in reliability-critical applications, such as offshore rigs. Because the inner workings are protected, they provide good service in corrosive and high/low temperature environments, and also in high pressure environments where the internal 'z' pattern of fluid movement can help to constrict flow.

Relief valves, also called Safety valves, are designed to contain pressure surges in a system or vessel to prevent damage from overpressure. Many designs and subtypes include all combination of safety and relief functions, and are referred to in combinations of the words safety, pressure, and relief.

- "Pressure safety valves" have a lever that activates manually or automatically, in event of overpressure. Some may use a diaphragm, while others use a spring, to 'pop' at a specific 'set pressure,' which typically follows a standard set by ASME, and which applies to a specific type of fluid or gas. ASME's boiler and pressure vessel code applies, as do standards by API (Practice 520/521), ISO (4126), European pressure equipment directives, and German standards).
- Low-pressure safety valves release automatically as the static pressure of a gas exceeds the set point. The relieving pressure is near the atmospheric pressure but positive.
- Vacuum pressure safety valves similarly release according to the static pressure of a gas. However, in this case the relieving pressure is near the atmospheric pressure but negative.
- Thermal Relief valves are designed to relieve thermal expansion of process fluids in vessels and long lengths of pipe, as temperature and pressure changes occur during changes to flow conditions. API codes apply, such as API 520.
- Bursting Discs provide a sacrificial disc that 'petals open' when pressure exceeds the set point. As opposed to being in a valve themselves, bursting discs may reside in the main body of the pressurized vessel or fit directly in pipelines.
- Pilot operated relief valves use a remote mechanism, which is connected to the upstream system, to detect pressure and then release the valve remotely. Pilot operated valves are often used in gas applications. It is important to minimize the delay between the pilot and the valve release action. Some are "snap acting," which implies conveyance of the signal and release of the valve within milliseconds.
- Modulating relief valves open in proportion to the overpressure. These are used to relieve excess pressure in pumps, piping, tanks, calorifiers, gas and oil separators, and other oil and gas pressure vessels that withstand fluctuating amounts of pressure in normal operation.

- Some definitions consider vents, screens, and traps that are used to relieve pressure created by fire or blow-out to be Relief valves, although these are excluded from the scope in this study.

Relief valves are used most frequently in downstream applications, such as refineries, in both gas critical and subcritical conditions (including flaring). Example applications include steam boil-off, tank pressure relief during filling or emptying. Relief valves can also include upstream applications such as mud pumping to assure overpressure protection.

Control valves, also sometimes called Regulating Valves, are designed to proportion flow. Nearly all types of valves, both linear and rotary, can be utilized as control valves to the extent that they are connected to power actuators, positioners, and other hardware and electronic accessories. Control valves typically include actuators and positioners, in addition to the valve itself. The actuation can be electric, hydraulic, or pneumatic. Primary applications considered are refinery applications such as catalytic cracking, Claus Process, and distillation. In more severe duty catalytic cracking processes, control valves are found between the regenerator and the flue gas recovery system, between the regenerator and the reactor, at the heavy gas oil entry to the heater, and between the reactor and the fractionation column. In the Claus Process, they are used between the combustion chamber and the Claus reactor, between the Claus reactor and the sulfur reservoir, and between the Sulfreen reactor and the secondary combustion chamber, in the distillation process, they are used at the entry of the feedwater to the heater, between the heater and the distillation tower, and between the distillation tower and the storage tanks.

Due to their electronic components, Control valves are sometimes considered part of Process Control (PCS or Process Control System) or Instrumentation rather than Valves. The remote actuation element of Control valves allows these valves to serve as one element of a system that can be optimized by regulating the speed, flow, and other parameters of not only multiple valves, but also other related equipment such as pumps and compressors. This can change a buyer's view of how to purchase them, and which suppliers are the best qualified to supply them.

The study generally focuses on valve sales to the oil, gas, petrochemical, and chemical industries since the reference products are specific to oil and gas applications. We deliberately focused on the portion of each supplier's business that pertains to our focus industries. We may still, however, reference information and analyses in a related industry when it has implications for the offering of those companies to the oil and gas industry. For example, there is substantial crossover with power industry applications. Also, we would cover a new technology for the desalination industry that has potential applicability in an oil and gas environment.

4 Legend

Abbreviations

API: American Petroleum Institute
ASME: American Society of Manufacturing Engineers
b: billions
Bpd: barrels per day
Bbl: barrel of crude oil
BTU: British Thermal Unit
CCGT: Combined Cycle Gas Turbine
CHP: Combined Heat and Power
Cfm: cubic feet per minute
E&P: Exploration and Production
EPC: Engineering, Procurement, and Construction
FPSO: floating production, storage and offloading
GW: gigawatts
k: thousands
kW: kilowatts
m: millions
MW: megawatts
M&A: Merger and Acquisition
MENA: Middle East and North Africa
Mmbtu: one million BTUs
MRO: maintenance, repair and operating
NGL: Natural Gas Liquids
Nm: Newton-meter
Psi: pounds per square inch
ROP: Rate of Penetration
t: trillion
Tons: short tons; Tonnes=metric tons
Tpy: tons per year
WTI: West Texas Intermediate crude oil
YOY: year over year
YTD: year to date

Alerts:

Yellow Alert (applies to any time period)

- Capacity margin < $150 million per year
- Capacity Utilization > 85%
- Important news

Red Alert (applies to next year only)

- Prices change 5%+
- Capacity margin < $100 million per year
- Capacity Utilization > 90%

Chart Symbols:

≡ Stable, ▲= Increasing, ▼ = Decreasing, LO = Low supplier concentration, ► = Moderate supplier concentration, HI= High supplier concentration

5 Methodological Notes

1. Demand is nominal (not real, inflation-adjusted), and is based on Sales excluding backlog that has not yet been recognized as revenue.
2. Prices are for new commitments. Average market prices typically lag the index based on the time it takes for pre-existing contracts to end or roll over. Price changes are nominal (not real, inflation-adjusted). Price changes are net of the cost of quality improvements, so actual market prices may exceed the amounts indicated.
3. Capacity includes base production capability plus plant openings and temporary capacity increases such as extra shifts, minus plant closings and temporary capacity reductions such as reductions of working hours or suspension of operations. Capacity estimates are unadjusted for possible efficiencies from process improvements. Capacity is adjusted for productivity improvements.
4. Capacity utilization means output as a percent of possible production, given no major investment. Capacity utilization rates are either self-reported or estimated. Orders above capacity to produce are considered backlog and do not result in capacity utilization rates above 100%. Overtime increases the capacity utilization rate and could make capacity utilization rates exceed 100%, whereas extra shifts count toward capacity and would not normally result in capacity utilization rates exceeding 100%.
5. Capacity Margin is the aggregate amount of available (unutilized) capacity based on utilization rates and total capacity. It is not adjusted for capacity that suppliers may have reserved for specific customers, so actual available capacity may be lower.
6. Order Lead Time is for Configure-to-Order (also called Assemble-to-Order), Make-to-Order, and where specified, Engineered-to-Order items, not for stocked/inventories items (for which lead time is very short). If categories consist only of stocked/inventoried items, lead time is not tracked. The basis is ex-works (from the time the order is placed until it is ready for shipping). Where there is a choice, Order Lead Time is based on oil and gas applications of higher-value items within each category (e.g., stainless steel rather than carbon steel, or with customizations such as ceramic coating).

6 Vital Statistics

Table 1: Order Lead Time, Capacity Utilization, and Prices

Metric	Time Horizon	Gate Valves		Globe Valves		Relief Valves		Control Valves	
Demand ($M, per quarter)	Q1 2013		366		115		121		479
	Q1 2015	▲	386	▲	121	▲	128	▲	508
	Q1 2020	▲	495	▲	152	▲	164	▲	645
	2013-2015	▲	5.5%	▲	5.5%	▲	5.5%	▲	6.0%
	2013-2020	▲	35.1%	▲	32.6%	▲	35.4%	▲	34.5%
Order Lead Time (Weeks)	Q1 2013		12.6		12.2		13.0		10.4
	Q1 2015	▲	13.0	▲	12.9	▲	13.1	▲	10.9
	Q1 2020	▲	13.1	▲	12.9	▲	13.1	▲	11.0
	2013-2015	▲	3.5%	▲	6.1%	▲	0.2%	▲	5.2%
	2013-2020	▲	3.8%	≡	6.1%	▲	0.2%	▲	5.6%
Capacity Utilization (%)	Q1 2013		75%		75%		75%		72%
	Q1 2015	▲	77%	▲	77%	▲	76%	▲	76%
	Q1 2020	▲	77%	▲	77%	▲	76%	▲	76%
	2013-2015	▲	2.0%	▲	2.2%	▲	0.9%	▲	3.0%
	2013-2020	≡	2.0%	≡	2.2%	▲	0.9%	▲	3.1%
Prices (Index 2005 Q1 =100)	Q1 2013		130.9		130.0		129.3		130.4
	Q1 2015	▲	135.2	▲	133.9	▲	133.2	▲	134.7
	Q1 2020	▲	148.7	▲	146.8	▲	145.8	▲	148.2
	2013-2015	▲	3.2%	▲	3.0%	▲	3.0%	▲	3.3%
	2013-2020	▲	13.6%	▲	12.9%	▲	12.8%	▲	13.7%

7 Gate Valves

7.1 Market Overview

Table 2: Key Indicators for Gate Valves

(Total Change over Each Period)

Key Indicators	Q1 2013 – Q1 2015		Q1 2013 – Q1 2020	
Demand Growth	▲	5.5%	▲	35.1%
Demand ($m)	▲	366-386	▲	366-495
Capacity Utilization	▲	2.0%	▲	2.0%
Prices	▲	3.2%	▲	13.6%

7.1.1 Demand

Demand for Gate valves rose 1.5% in Q4. It will rise 0.2% each in Q1 and Q2. Demand is growing at 5.5%/year and will rise 35% in the next seven years.

Gate valves are consumed by the Chemical, Oil & Gas, Water and Wastewater, Power, and Manufacturing industries. Power, Upstream Oil & Gas, and Downstream Refining account for 17%, 16%, and 15% of total consumption, respectively. The Wastewater, Chemical, Pulp & Paper, and Iron & Steel industries each account for 2-8% of total demand. The remainder comes from the Food, Pharmaceutical, Metals and Mining, and Electronics industries.

- Chemical manufacturers have rebounded from the recession and are investing once again in plants. New plants use Gate valves in a wide variety of applications where full shut-off and full-throttle operation is desired, and replacement units are frequently installed during plant refurbishments and turnarounds
- The Oil & Gas industry is currently a strong demand driver due to numerous megaprojects around the world. In the West, shale gas is propelling massive investment in rigs that use Gate valves at wellheads. In the Middle East and Africa, massive upstream projects such as Maersk Oil's Chissonga project (off of Angola) and Saudi Aramco's Jizan refinery project are consuming Gate valves.
- Power producers in the developing world are erecting new power stations to fuel industrial production (at the aforementioned chemical and oil & gas facilities, as well as for consumer demand). China, India, Saudi Arabia, the UAE, and Brazil are investing the most and the fastest. Gate valves are used in the steam generation process in cogeneration (combined heat and power) and combined cycle plants as drain valves, by-pass valves, and equalizing devices.
- The iron & steel industry will grow 5.9% in 2013 due to rebounding steel prices in response to industrial and infrastructure growth in developing economies in Asia and Latin America.

The broad base of usage requires large manufacturers to operate globally. Most suppliers supply projects far outside their home countries, for example:

- Amaturenfabrik Franz Schneider GmbH will supply gate valves among other equipment to Sadara Chemical in Saudi Arabia, the largest plant of its kind in the world.
- Flowserve is supplying gate and globe valves for two new nuclear plants in China in a $15 million contract with China's State Nuclear Power Engineering Company (SNPEC).
- Weir Minerals Africa supplied 67 knife gate valves to a gold mine in Burkina Faso, starting in May 2012.

The Oil & Gas industry in particular is a strong driver of demand for Gate valves, especially in pipelines. Oil & Gas demand will grow as a proportion of the total Gate valve demand more than any other industry between 2010 and 2015, rising from 15.2% to 15.7% of total demand (excluding Refining). Upstream, Gate valves are being used in the drilling standpipe manifold, pump manifold block valves, mud mixing lines, drilling system flow control, wellheads, and in production manifolds, gathering systems, and flow lines. Downstream, Gate valves are being combined with special sealing and even leak detection in refinery applications, such as in a hydrofluoric alkylation unit.

Gate valves are particularly used in oil and gas pipelines that require full throttle operation. In these cases, high-pressure flow would erode the materials of the inner working in less robust valves such as butterfly or ball valves, while gate valves are less vulnerable because the gate does not remain in the process fluid. Thirty thousand miles of pipeline are currently under construction worldwide, mostly for natural gas. Regionally, pipeline activity is dispersed, coming predominantly from Asia and North America, but with large proportions in Russia, Eastern Europe, and South America.

Numerous Asian pipeline plans will drive demand for Gate valves. There are plans for 34,295 miles of pipelines in Asia Pacific, versus 31,951 in North America (driven largely by shale gas production), and 19,537 in the Former Soviet Union and Eastern Europe. South America, the Middle East, Africa, and Western Europe are also building pipelines to support their projects, but they involve less mileage, so will not have as big an influence over valve demand.

Asia Pacific accounts for the largest number of new and planned pipeline miles to be built. Most of this work is concentrated in India, China, and Australia. There are 14,061 miles of pipeline in various stages of construction, and 20,234 miles in the engineering and design phase.

- China's second huge West to East natural gas pipeline, which was recently completed, will carry 30 bcm per year from central Asia to the Yangtze and Pearl River Deltas. A third, fourth, and fifth version of this same pipeline are also being planned for different latitudes.
- Gujarat State Petronet Ltd. in India will build three major pipelines totaling 2,500 miles.

- There is also LNG pipeline construction activity in Thailand (a 185-mile pipeline, to be built by Punj Lloyd).
- In Australia, Santos GLNG will build a 261-mile gas pipeline from gas fields in Gladstone to a processing plant on Curtis Island.
- In Papua New Guinea, Esso Highlands Ltd.'s PNG LNG project will build a 435-mile pipeline from Southern Highlands to Port Moresby.

Mostly due to the booming shale activity in North America, at least eight major pipeline projects total over 5,600 miles of pipeline under construction and 26,000 in the planning stage. Some projects of note include:

- Pending approval, TransCanada's 1,661-mile, $7b, 36-inch Keystone XL crude oil pipeline will run from Alberta to Nebraska.
- DCP Midstream is building a 700-mile, 120k bpd 'Sandhills' Pipeline from West Texas to East Texas
- Greencore Pipeline is building a 231-mile, 20" CO_2 pipeline from Wyoming to Montana to support enhanced oil recovery pressure pumping there.
- Kinder Morgan's Cochin Marcellus Lateral Pipeline will carry NGL from the Marcellus shale in Pennsylvania to fractionation plants and petrochemical refineries in Illinois and Canada.
- Enterprise Products Partners is planning a 1,230-mile, 125k bpd ethane pipeline from the Marcellus and Utica shales to Texas.
- Oneok Partners is building a 570-mile, 16" pipeline from the US Midwest to Texas.
- ExxonMobil is still working on plans for a 1,717-mile pipeline from Alaska's North Slope to the Alaska/Canada border.
- Additional projects in Canada (McKenzie Valley) and Mexico (McDermott) remain in the planning stages.

The Former Soviet Union's countries have been constructing pipelines that connect them with Asia Pacific and Europe, and have more on the way.

- Nord Stream's twin 760-mile pipeline began operation in late 2012. The pipelines will have capacity to transport a total of 55 Bcm of gas a year to the EU. Line 1 began transporting gas in June 2011, and Line 2 opened in November of 2012.
- In Russia, Transneft's 310-mile Zapolyarye-Purpe pipeline will transport up to 45 MMt/a of crude from the Yamal and northern Krasnoyarsk territory to the Eastern Siberia-Pacific Ocean pipeline (ESPO). The network will expand to 750 miles of pipeline.
- The 916-mile Kazakhstan to China pipeline was completed in late 2012, and a 193-mile addition is planned for 2014-15 from Beineu–Bozoy to a compressor station in Karaozek.
- Several other potential pipelines are in the planning stage, including Gazprom and China National Petroleum Corporation (CNPC)'s 1,616-mile Altai natural gas pipeline from

western Siberia to northwestern China, BP's Shah Deniz pipeline, and two other proposed pipelines that could ship Azeri gas to Europe.

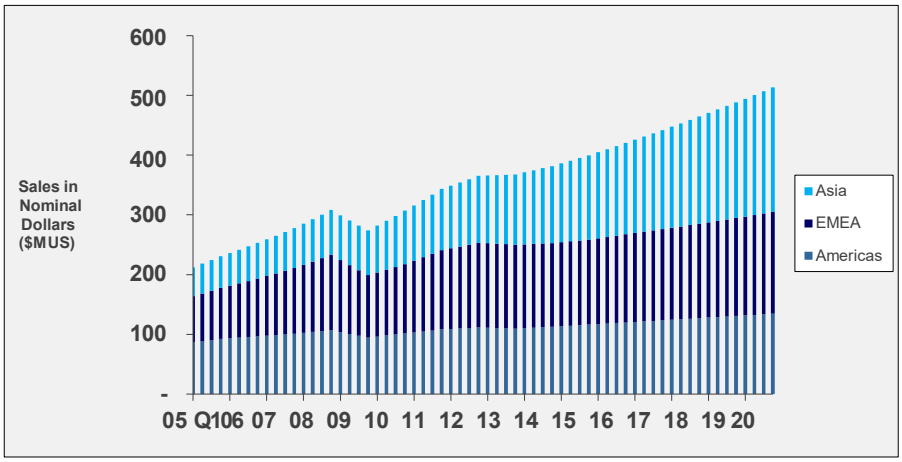
South and Central America have several plans for constructing new pipelines, notably Petrobras's pipeline from Minas Gerais and Sao Paulo to Rio de Janeiro. In Colombia, Pacific Rubiales Energy Corp. and EXMAR plan to develop an LNG export project from the La Creciente gas field to the Caribbean coast. In the Middle East, 9k miles of pipelines are being designed and around 2,700 miles are being built. Africa, suffering from economic and political unrest, plans to build only 7,617 miles of pipeline. Due to the European economic crisis, current plans only call for 2,172 miles, and if the current economic and social malaise continues there, none of that may happen at all.

Geographically, demand for Gate valves is shifting from America and Europe to Africa and Asia. America, which constituted 21% of global demand for the chemicals, oil and gas, and refining industries in 2010, will lose 2% of that share by 2017. Western Europe, which constituted 14% of the global demand, will cede 3% to other world areas. The largest increase in consumption of Gate valves for the chemicals, oil and gas, and refining industries will come from projects in China, Nigeria, Japan, and South Korea. Indonesia and Algeria will also experience growth.

- In China, all major IOC and NOCs are investing in greenfield facilities. Total, Shell, Chevron, and BP are all active with Chinese partners, and most have international procurement offices in Beijing. Saudi Aramco has developed local procurement capabilities, and has begun sourcing from Chinese suppliers.
- In Nigeria, NNPC has numerous joint ventures underway for both oil and gas processing, and has just committed, after an extensive evaluation, to build new greenfield refineries. In addition, private interests are investing in offshore gas processing operations, which will require pipelines to shore, thereby driving the need for Gate valves.
- In the Far East, JGC is investing heavily abroad through joint ventures, for example in the Middle East. If it follows the Korean pattern, it will opt to source the majority of its equipment such as Gate valves from local companies, thereby driving up sales in those countries.

Globally, sales of gate valves will increase by 5.5% by 2015 and 35% by 2020, with the majority of the growth coming from Asia.

Figure 1: Demand for Gate Valves



7.1.2 Supply (Capacity)

Capacity will rise by 2.7% by 2015 and 33% by 2020, slightly lagging demand as suppliers 'chase' demand rather than take the risk of overbuilding, being cautious of the potential for another recession.

The top Gate valve manufacturers for this type of application are:

- Flowserve
- Cameron
- Crane
- JC valves
- Velan
- Tyco/Pentair
- Valvitalia
- MTS
- Circor
- MSA

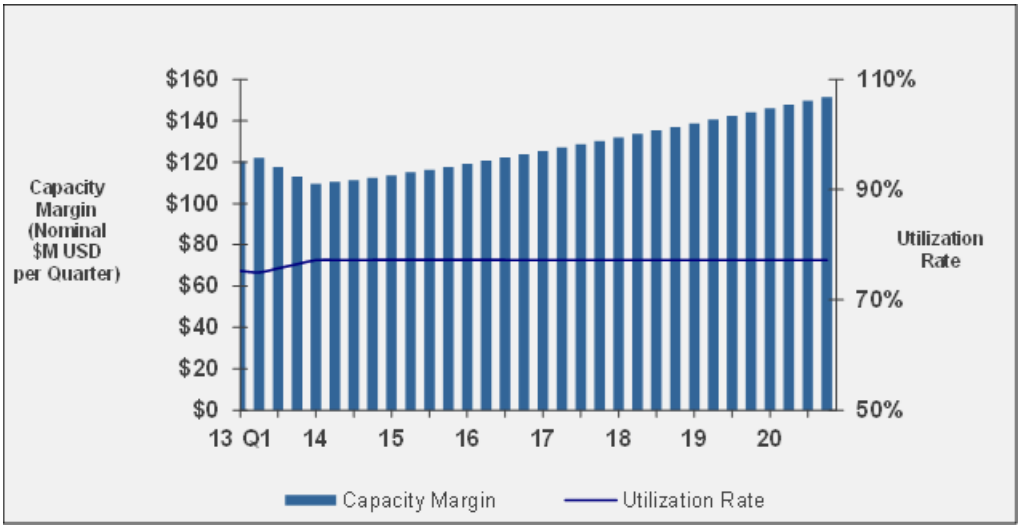
Total Gate valve capacity is increasing, as suppliers add and expand plants to accommodate sales growth. Current capacity margin is about $60m, which is sufficient to accommodate orders for multiple megaprojects at once, so buyers do not need to formulate major strategic agreements for fear of supply shortage. The capacity will come with a lag: net capacity will not increase in 2013, but suppliers are planning to add about 3% new capacity in 2014 and almost 5% in 2015.

About half of the major suppliers of Gate valves have recently added capacity to make Gate valves, notably Velan, JC Valves, Flowserve, KSB, and Tyco. Mostly these were joint capacity increases that applied to globe, and sometimes to relief, valves as well.

- Flowserve added capacity in Italy for gate, globe, and relief valves in 2012.
- KSB added capacity in China for gate and globe valves in 2011
- Tyco added capacity in the USA for gate, globe, and relief valves in 2010
- JC Valves opened a wholly-owned subsidy started in the UAE to produce gate, globe and check valves of 1/2" to 24" in 2012.
- Velan increased capacity for gate valves in India in 2012. The 100k square foot Coimbatore factory will initially produce small forged valves before expanding to make units for the energy and fertiliser industries. Velan is also expanding production at its Chinese and Korean plants, as well as increasing output in North America.

Capacity utilization is steady today, at 75%. This will increase progressively to 77% over the next 12 months, where it will plateau as capacity additions come onstream. Notably, neither Cameron nor Crane are adding capacity, or at least they have not shared their plans. This could result in extending lead times from Crane, which is already operating at 80% of capacity.

Figure 2: Capacity Margin - Gate Valves



Overall, capacity utilization will tighten slightly (by 2%) over 2013-2015 until suppliers add capacity to cover the gap. From 2015 through 2020, capacity additions will kick into effect, while demand slows, resulting in more capacity margin. Buyers with construction scheduled for 2015 and beyond

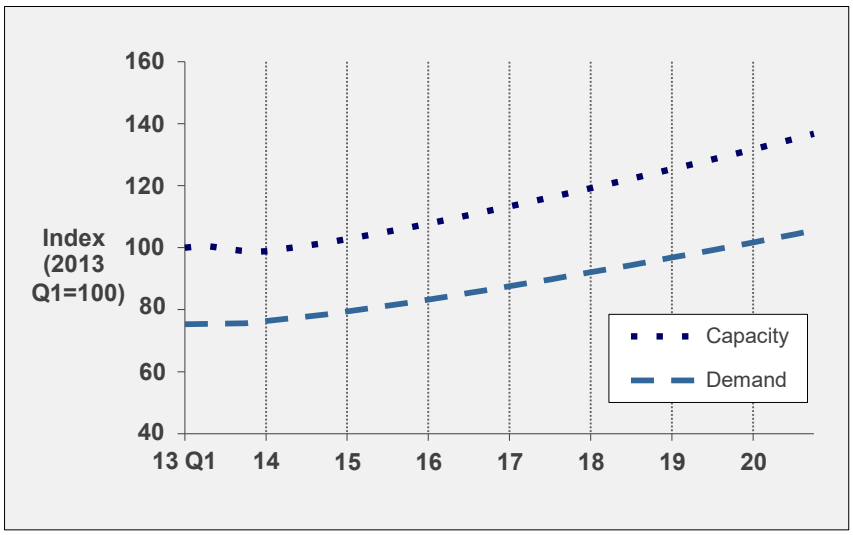
may want to defer their commitments until the new capacity comes online and they have more bargaining power.

Table 3: Reported or Estimated Capacity Utilization Rates at Selected Gate Valve Suppliers

Company	Country	Current Level	12-Month Forecast
Crane	China	80%	82%
Flowserve	Worldwide average	70%	79%
MSA	Czech Republic	85%	75%
MTS	China	80%	80%
Sodeco	Spain	70%	70%
Tyco	UAE	70%	70%
Tyco	Worldwide average	75%	75%
Valvitalia	China	70%	70%
Valvitalia	Italy	70%	70%
Velan	Worldwide average	80%	82%

Flowserve expects its capacity utilization rates to increase substantially over the next 12 months. Tyco estimates that its utilization rate will increase by 9%. Since Flowserve is the leading supplier of Gate valves in the world, having more than twice the sales of the next largest supplier (Cameron), we expect Flowserve to raise its prices incrementally, thereby creating a 'price umbrella' from which all the other Gate valve suppliers will benefit.

Figure 3: Demand vs. Capacity - Gate Valves



7.1.3 New contracts

Velan scored big with large orders for the nuclear power industry in China. Its new contracts for Gate valves are coming largely from emerging countries, especially in Asia. China, India, Turkey, Slovakia, Bahrain, and Africa placed the biggest orders.

Major new contracts have boosted Velan, Flowserve, and smaller Asian gate valve suppliers.

- Velan signed a $19m contract with Mochovce nuclear power plant in Slovakia to provide Gate, Globe, Check, and Butterfly valves. The deliveries started in 2011 and extend several years.
- Velan was also selected by China Nuclear Power Engineering Co. (CNPE) and by China Nuclear Energy Industry Corporation (CNEIC) to supply Gate and Globe valves for their nuclear plants. Moreover, Velan has been awarded aftermarket contracts from DNMC (Daya Bay Nuclear Power Operations and Management Co.) for one of its nuclear plants. All those contracts combined had a value of $ 16.2 million, for delivery between 2012 and 2014.
- Flowserve received a multi-million dollar contract from Korea Hydro & Nuclear Power Co. (KHNP) to provide Gate and Globe valves for the Shin-Ulchin plant, which will start by 2016.
- Essar Oil Refinery signed up for $10.25 million of gate and globe valves from CRI valves. The deal will include 500 gate and globe valves.
- Shell signed a 5-year supply agreement with Flowserve for gate and check valves. We estimate the value of the deal, which is global in scope, to exceed $10m.
- Shell signed a $10m+ contract with Tyco for 2500 'butterfly gate' valves.
- Technip contracted Shipham Valves (UK) for 46" gate valves for Bahrain Petroleum Company's steam turbo generator seawater intake mechanism. At nearly five and a half meters high and weighing more than seven tonnes, these are the largest gate valves manufactured from nickel aluminum bronze (NAB).
- China Nuclear Power Engineering) Corporation (CNPEC) awarded a $2 million contract with Gate, Check and Globe valves to China Valves Technology.
- NRG Big Cajun Power Plant in Ventress, Louisiana bought three DN 300 Larox wafer knife gate valves, with a cast body and a heavy-duty stainless steel gate, for fly ash control. Together with two that the company had bought previously, this makes five of these gate valves. They achieve a tight seal due to their removable seats on either side of the blade, and they are protected from corrosion because they have no metal parts in contact with the slurry.

Based on oil and gas activity and the fundamental underpinning demand, the outlook for new Gate valve contracts looks strong through 2015 and even 2020. In particular, large projects such as the pipelines mentioned earlier have yet to place major orders, including:

- TransCanada's $7b Keystone XL Pipeline in the US.
- CNPC's 550k bpd oil pipeline and 12 bcm/d gas pipeline, each 500 miles long. In a second stage, the two pipelines will be extended another 1,056 miles.
- The 310 mile Zapolvarye-Purpe Russian pipeline, which will have a capacity of 45 MMt/a of crude. It will be constructed in three phases and will be completed by 2016.
- Gazprom's increasing exploration and production activity in Siberia.

Table 4: Summary of New Contracts and Estimated Values for Gate Valves

Buyer	Country of Installation	Supplier	Product	Estimated Value ($m)	Estimated Cost/Unit ($m) (Gate Valves)
CNPE	China	Velan	Gate and Globe	$61	$336
National Thermal Power Corporation	India	Velan	Globe and Gate	$20	$228
Mochovce Nuclear Power Plant	Slovakia	Velan	Gate and Globe	$19	$630
CNPE	China	Velan	Gate and Globe	$16	$336
KHNP	Korea	Flowserve	Gate and Globe	$15	$479
Shell	Global	Tyco	“Butterfly gate”	$10+	$411
Shell	Global	Flowserve	Gate and Check	$10+	$404
CNPE	China	China Valve Technology	Gate, Globe, Check	$ 2	$336
Bissa Mining Project	Burkina Faso	Weir Minerals Africa	Gate (knife)	$0.3	$4,100
Essar Oil Ltd.	India	CRI Pumps Pvt Ltd.	Gate, Globe, and Check	$0.2	$2,000
ABB	Africa	OMB	Gate and Globe	Unknown	Unknown
SK E&C	South Korea	OMB	Gate and Globe	Unknown	$479
NRG Big Cajun Power Plant	US	Larox Flowsys Group	Gate (knife)	Unknown	$617

7.2 Analysis

7.2.1 Costs

Overall, gate valve costs will increase at 1.5% per year through 2015, and 1.8-2.2% per year from 2016 through 2020.

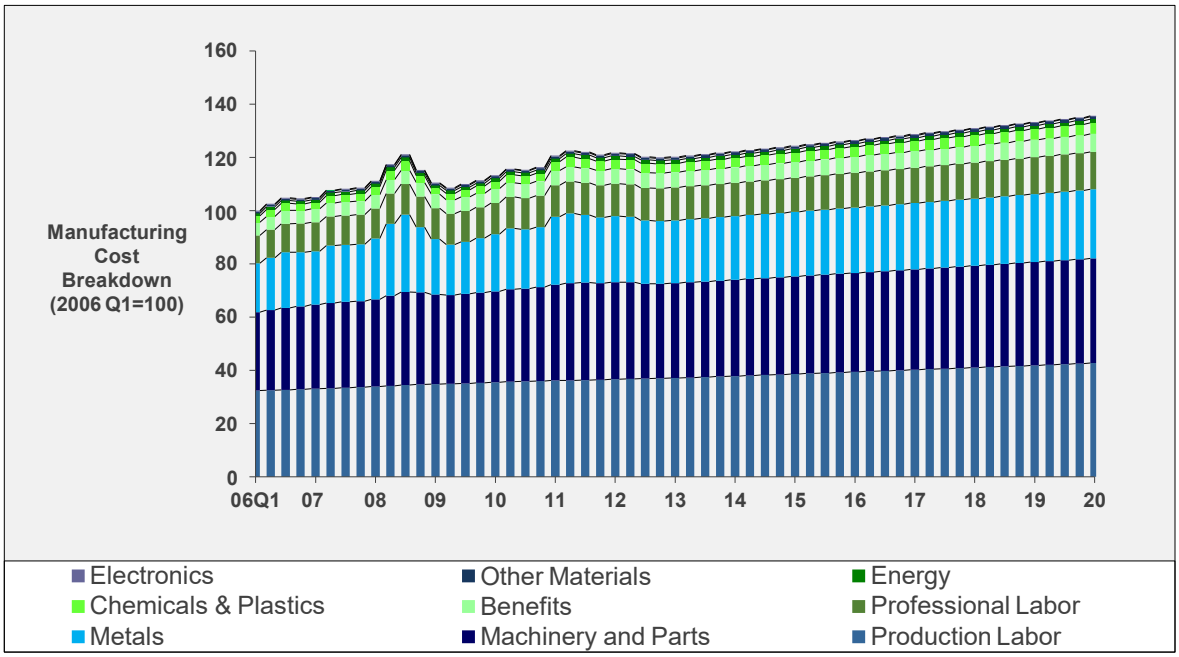
Making Gate valves to API specifications is labor intensive. Over 40% of the cost comes from professional (engineering and management) labor and production labor.

- Production labor and benefits costs are growing predictably at 0.5% per quarter, or 2-3% per year.
- Professional labor is exhibiting similar inflation in developing economies, but much higher growth rates in emerging economies such as China and India. For example, the provincial capital of Guangzhou raised its minimum wage by 19% in February.

30% of the total cost comes from various metals and fabricated metal shapes and components. Metals are forecast to grow at 0.3% per quarter, or 1.5-2% per year.

- Machinery and parts costs are growing at 0.4% per quarter, mostly on technology improvements, engineering labor, and exotic metals costs.
- Some chemicals and plastics are used; however their proportion is small enough that they are not price drivers.

Figure 4: Cost Structure of Gate Valves



Note: Prices are ex-works.

7.2.2 Profit Margins

Gate valve suppliers earn margins consistent with other manufacturing companies operating in competitive global marketplaces.

Gate valves are essentially “commodities." Vendors have a common “list” price they refer to as “published price.” These products are less customized than Control or Relief valves.

In addition, most Gate valves are sold through 3rd party integrators or distributors, under the label of ‘Pipes, Valves, and Fittings,’ or PVF.

Most large vendors and integrators seek the large scale facility retrofits for volume.

Due to the above factors, Gate valves sell for a much lower price point than any of the other three types of valves studied in this analysis. The average selling price is $617 per unit, compared to $822 for globe valves, $15,132 for relief valves, and $8721 for control valves.

However, Gate valve manufacturers earn a healthy total profit margin dollars by selling in

high volumes. The average operating margin of a benchmark of Gate valve manufacturer is 9.1%, and their net margin is 6.4%.

- Flowserve, which sells about 10 times more Gate valves than any other type of valves, earned 13.3% operating margin and 9.5% net margin.
- Velan, which is similarly skewed toward Gate valves, earned 7.6% operating margin and 5.6% net margin.
- Cameron, whose Gate valve sales form the largest share of the company's valve revenues, earned 10.7% operating margin and 7.5% net margin.
- Crane, whose sales are also heavily weighted toward Gate valves, earned 1.7% operating margin and 1.0% net margin.

Higher-priced Gate valves earn higher margins. For example, the price of a Gate valve can approach $100k for a 12" diameter, 1500 pressure class, 317L stainless steel unit. Suppliers earn a higher profit margin on sales of this type of unit than they do on the low-end, high volume, simple Gate valve. However, few of these are sold, so it doesn't visibly affect their bottom line results. Based on a cost structure consisting of 40% labor and 40% materials and 20% overhead, and assuming it takes half as much material to make one large unit as many small units, gross margin would be 20% higher for the larger unit. Further assuming that operating margin is half of gross margin, operating margin would be 10% higher for the higher-end products.

The Gate valve market is a stable one. While prices vary somewhat from quarter to quarter and move by fractions of a percent, capacity utilization moves within a similarly narrow band, and so does lead time, which is correlated with backlog. Order lead time is 12.6 weeks for a normal order. This will increase by 3-6% over the next 2-5 years as demand growth outpaces supply, but this will occur in a stable and progressive fashion.

Therefore, we see no current market anomalies that would create unique buying thre ats or opportunities.

7.2.3 Prices

Prices, which are often quoted as a discount off 'list,' have risen with inflation.

Because of the vast number of combinations of size, pressure class, and materials, prices are often negotiated as a percent off list price rather than as individual prices for each valve. Discounts for Gate valve contracts are likely to range from 10% to 25% off what insiders refer to as the "published price." Small contracts are often discounted at 10-15% off list, while medium contracts sell for 15-20% off, and large contracts sell for 20-25% off list price.

Here are some examples of how the pricing works:

- China Nuclear Power Engineering Co., Ltd signed a $2m contract for Gate, Globe, and Check valves (with Velan) at what is likely to be a 15-20% discount off of list price.
- Shell negotiated a global five year supply agreement with Flowserve that probably enabled it to achieve a 25% discount off of list price for Gate and check valves.
- Shell also contracted for 2500 butterfly Gate valves at a 22-25% discount off Tyco's list price.

Since 2005, prices for Gate valves have risen approximately 23% (in Europe) to 32% (in Asia), net of volatility throughout the 2008-2009 boom and bust. EMEA prices rose the least, while Asian prices rose the most – at 32%.

More recently, aggregate prices for Gate valves rose 1% in Q1 and will rise 0.2% in Q2. By the end of 2015, they will rise 13.6%, reflecting some of the price inflation we predicted earlier, as suppliers take advantage of economic growth to push through price increases that boost their profit margins.

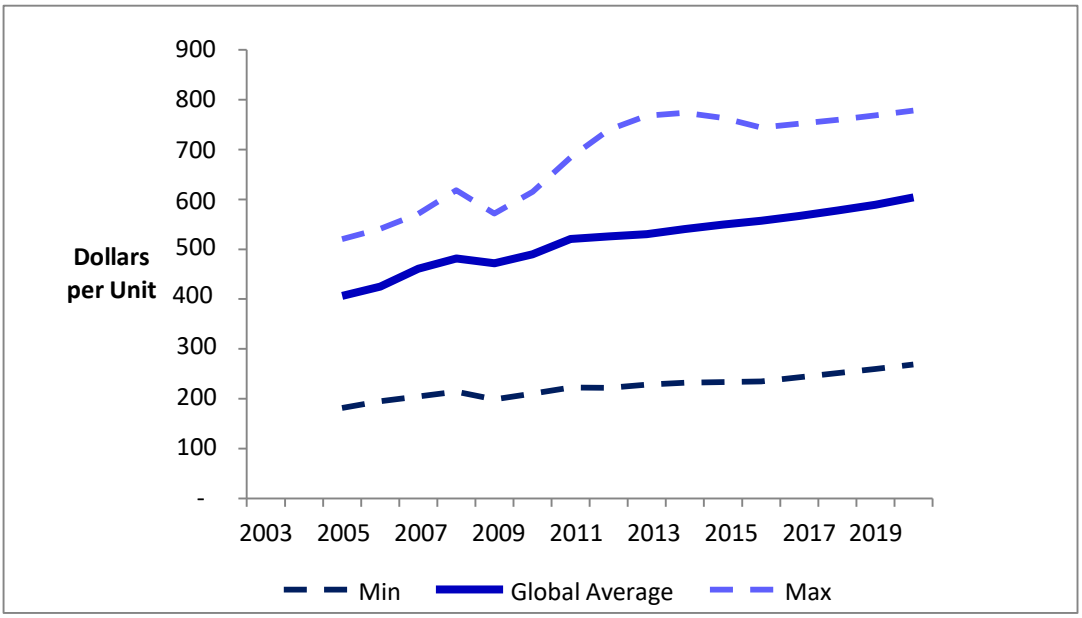
By 2020, Asian prices will grow 15%, while American prices will grow 13% and EMEA prices 12%. This reflects a substantial leveling of the price field compared to previous years, in which Asian prices grew much faster year on year than their counterparts in the Americas and EMEA.

- Price in Asia will grow slower in 2014 and 2015 as China's economy takes a pause from its 8% or more annual growth.
- Meanwhile, prices in the Americas should increase at an increasing rate, as the US economy comes out of its slump in 2014, 2015, and 2016.

- Prices in Europe will grow the slowest, as a result of the European debt crisis and general economic malaise.
- By 2017, Asian prices will be growing faster again, at over 2% per year, while American and European prices will slump back to 1.5-2% per year.

Large buyers will find less opportunity for discounts than they are used to by shopping in the traditional Chinese markets. Instead, they will need to look more carefully at emerging markets such as Turkey and Korea.

Figure 5: Overall Price Forecast for Gate Valves



Japan, Europe, and the United States have the highest Gate valve prices. The baseline cost of a 6" diameter Gate valve of carbon steel with SS 316 trim and pressure class 150 and a maximum working temperature of 800° F, made to API 600 or 602, is $617 in the United States. The US is one of the more expensive countries based on its higher cost of professional and engineering labor in the US, and even production labor is more costly on the global scale ($18-20 per hour).

Compared to this baseline:

- Japan's high cost of electricity and labor drives its costs 24% higher. Electricity is about 230% of that in other countries, and labor is 175% higher.
- Europe's cost is 2% above the US cost as a result of the high social costs of its workforce.

The lowest-cost producers of Gate valves are India, Eastern Europe, and China.

- India has low costs for both labor and steel, making it far less expensive than most other countries. The cost of labor in India is approximately $4 per hour.
- Eastern Europe, including Turkey, which is in negotiations to join the EU27, has a very low cost of labor, and manufacturers have used it as the next low-cost manufacturing and export platform after Asia. However, price quotes for small volumes can be excessively high and completely out of market range. Suppliers are either set up for high volume global scale or they are not, and if they are not, they will not be price-competitive.
- China has not only a low cost of steel, but a huge number of suppliers that are all operating in a competitive, export-driven sales stance, although its recent price inflation has stripped it of its previous lowest-cost ranking. Chinese prices for our reference Gate valve averaged $370 per unit for an order of 500 pieces. Bidding in China requires significantly more time to screen out unrealistic and misunderstood quotes. For example, one RFQ for Gate valves received quotes between $217 and $945 for the same product with same specifications.
- Prices in other Asian countries, such as Korea, are higher than China's but lower than those in Europe, the Middle East, and Russia, making those countries ripe for global sourcing initiatives for Gate valves. African costs are lower, too, but locally manufactured product is not of comparable quality.

Latin American is neither high priced nor low priced on the global scale ($552 per unit), but there is wide price variation within Latin America. Argentina's and Brazil's costs are more like those of Europe, while Mexico's are more like those of China.

Although Russia has lower labor costs than many other countries (more than three times that of India, but less than half of European wages), the country has a high cost of power, especially electricity, and a higher cost of rubber and plastics than many other countries. One Russian bid for Gate valves came in at $668, higher than the US.

Table 5: Regional Price Variations over Time for Gate Valves

Region/Country	Today	2014	2015	2020
North America	1.00	1.02	1.00	1.05
Latin America	0.89	0.93	0.95	1.15
Europe	1.02	1.03	1.02	1.09
Africa	0.93	0.94	0.93	1.03
India	0.37	0.38	0.38	0.44
Russia	0.96	1.01	1.01	1.20
China	0.55	0.55	0.54	0.58
Japan	1.24	1.25	1.24	1.26
Other Asia	0.78	0.78	0.78	0.80

7.2.4 Price Differences by Technology, Model, and Feature

Aside from competitive and global economic forces, and negotiating strategies, three physical characteristics can significantly alter the price of Gate valves: size, material, and pressure class.

When considering the baseline to be a simple Gate valve of carbon steel and 150 pressure class, here are some of the relationships between these variables and the cost:

- Change the pressure class from 150 to 300, requires the thickness of the wall to increase, and consequently the price will increase by 40%
- For every inch of additional diameter, the price of a carbon steel Gate valve increases by $1,900. Increasing the size from 6" to 12" increases the price by 80%.
- By changing the materials from carbon steel to stainless steel, the price increases 3.5 times.
- For a 6" Gate valve, moving from carbon steel to 316 stainless steel triples the price, and moving from carbon steel to 317L stainless steel almost quintuples the price.
- For a carbon steel Gate valve, increasing the pressure class adds $13 for each unit of additional pressure class rating.

These relationships are depicted in tabular and graphic form below.

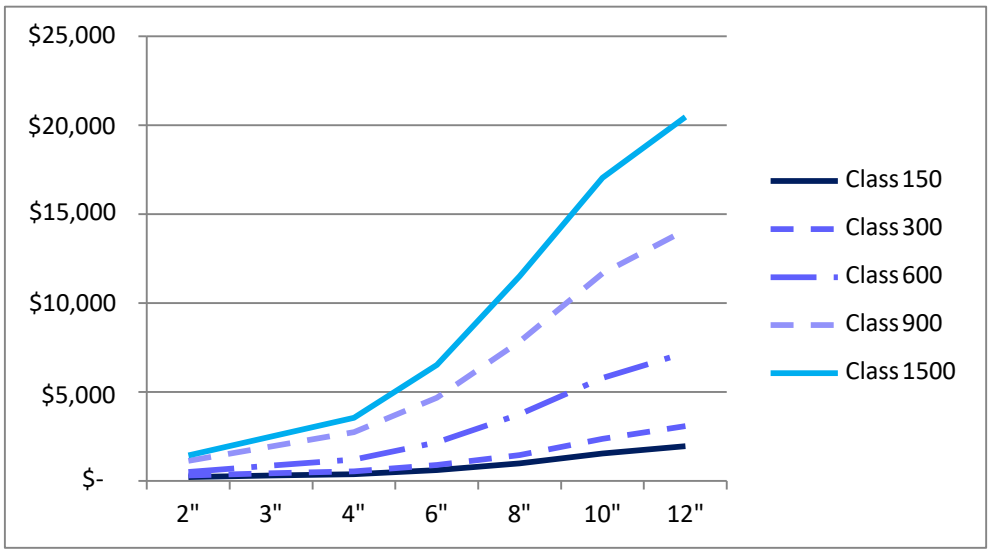
Table 6: Incremental Cost per Extra Parameter or Feature for Gate Valves (relative to a unit of carbon steel, 150 pressure class)

Parameter or Feature	Unit of Measure	Indicative Cost Impact	Notes / Comments
Size	Diameter (inches)	$173/inch (based on carbon steel)	Cost grows exponentially with size
Material	Carbon steel as reference point	3.29x for stainless steel 316	5.09x for Stainless 317L
Pressure Class	150, 300, 600, 900, 1500	+ $4.38 per incremental pressure class rating	Cost grows exponentially with pressure class

Note: Changing one parameter usually involves changing others, and the cost impact may not be additive or linear.

As noted above, the cost of an extra inch in diameter increases the price of the valve exponentially. But starting at a 10" diameter and up, the rate of increase will be lower, at about $ 200/inch. This is due to the smaller difference in prices between a 12" diameter unit and a 10" valve compared to the difference between a 10" diameter and an 8" one.

Figure 6: Gate Valve Size vs. Cost – by Pressure Class



The increase in size offers valuable benefits, however. For Gate valves, each inch increase in diameter yields more flow. The cost/benefit ratio improves as the diameter increases. For example, an investment in a 10" valve is expensive, but it generates a proportionally much higher incremental increase in flow than moving from a 3" to a 4" Gate valve.

Figure 7: Gate Valve Size vs. Cost – by Material (150 pressure class)

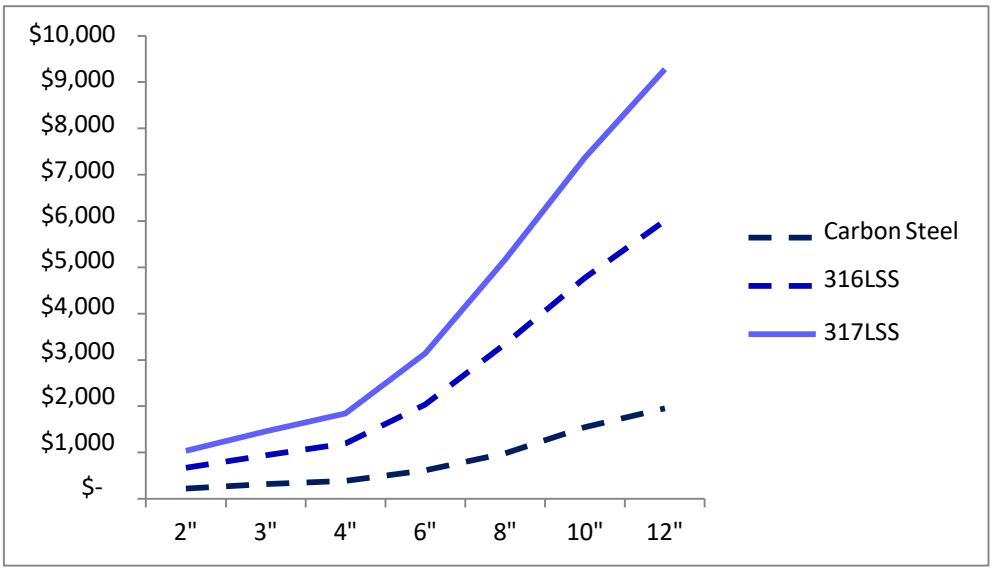
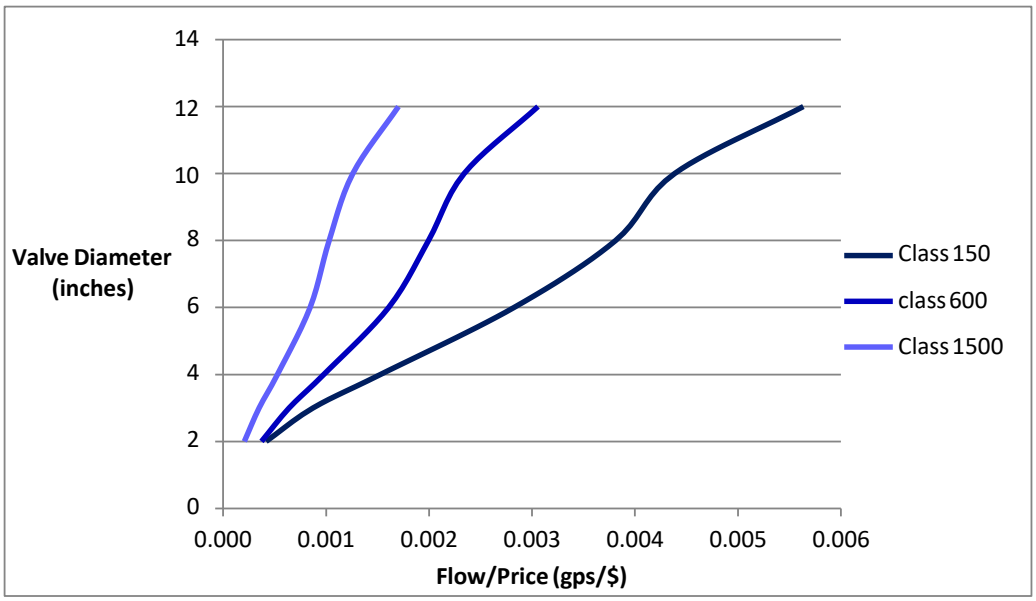
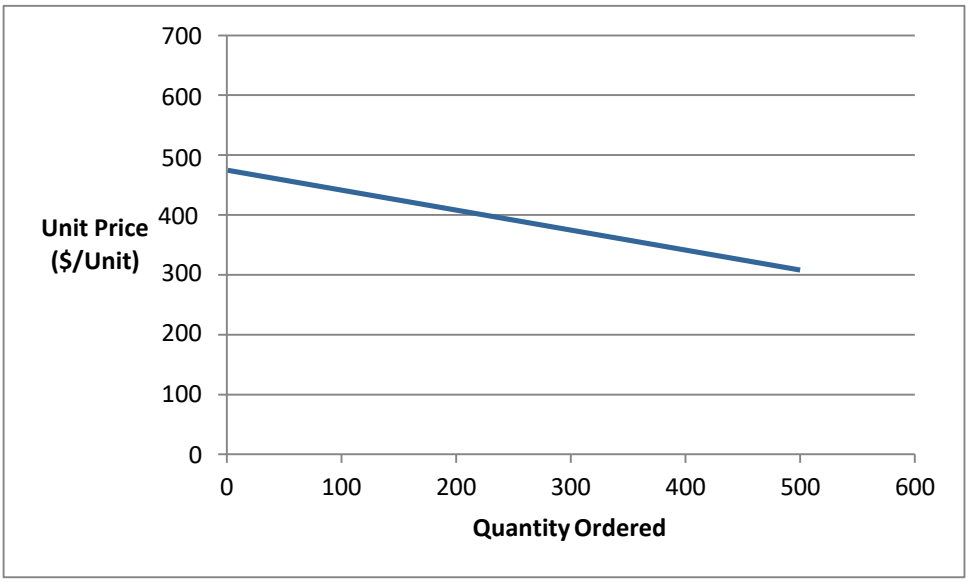


Figure 8: Output flow for each extra Dollar spent vs. Gate Valve size – by Pressure Class



Buying Gate valves in bulk reduces unit cost. Using a sample of bids, we demonstrate below that for every additional valve ordered, the cost per valve would decrease by $0.33.

Figure 9: Economies of Scale in Gate Valves



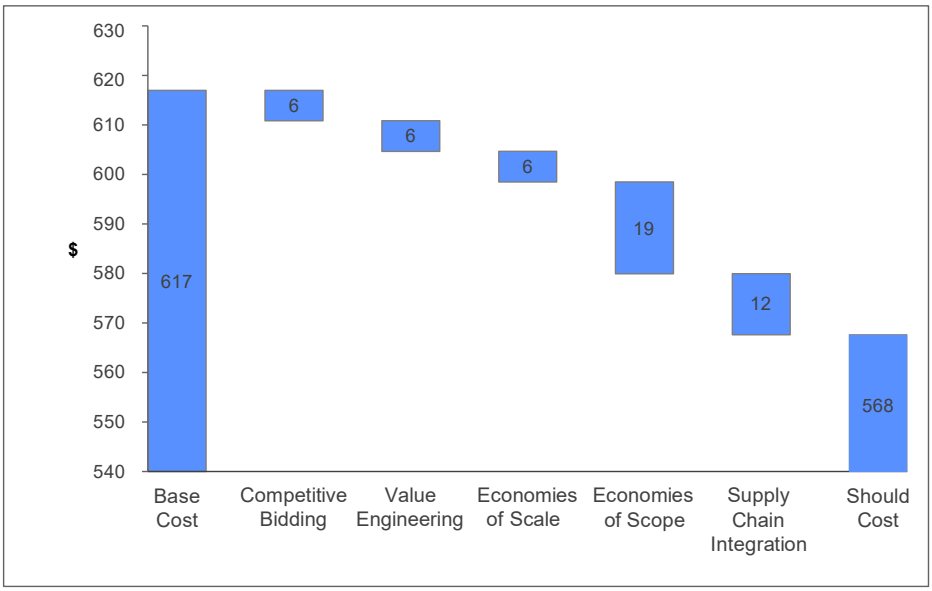
7.2.5 Should-Cost Analysis

Oil companies like Shell, Total, BP, and Saudi Aramco have all implemented category management organizations by now, to varying degrees. Valves is a distinct category, although they have different ways of subdividing the valves market. Some carve the market by application, while others do it by physical market and/or by geography.

In any case, the way toward high-potential savings in this relatively high-volume market depends on economies of scope

- Eliminating excess profit margins: 1%
- Ordering in bulk quantities: 1%
- Negotiating bundled packages together with other products or services: 3%
- Integrated stocking and collaborative inventory planning: 2%
- Signing long-term agreements at lower rates due to reduction of market risk: 2%

Figure 10: Should-Cost for Gate Valves (US Basis)



7.3 Price Negotiation Strategies

1. Negotiate framework agreements with core suppliers and target getting the 25% discounts off of list price in exchange for volume and long-term commitments.
2. Order in bulk quantities using the economies of scale, and quantifying the benefits.
3. Launch a well-resourced global sourcing initiative to profit from regional variations in costs and prices. Probe the opportunities in markets such as India, China, and Turkey.
4. Investigate an alliance with Canadian supplier Velan; it has won major contracts and is on the cusp of moving from a small to a global supplier.
5. Require annual efficiency gains that offset the predicted market price increases.
6. Embed vendor-managed inventory in contract negotiations.

8 Globe Valves

8.1 Market Overview

Table 7: Key Indicators for Globe Valves

(Total Change over Each Period)

Key Indicators	Q1 2013 – Q1 2015		Q1 2013 – Q1 2020	
Demand Growth	▲	5.5%	▲	32.6%
Demand ($m)	▲	115-121	▲	115-152
Capacity Utilization	▲	2.2%	▲	2.2%
Prices	▲	3.0%	▲	12.9%

8.1.1 Demand

Demand, heavily stemming from the oil and gas industry, is shifting noticeably toward Africa and East Asia, where large exploration and production activities will be ongoing through at least 2017.

Globe valves are used in a wide variety of industries, with the largest shares in the power and process industries. The split of purchases, by industry, in 2012, was:

- Power 17%
- Refining 15%
- Chemical 10%
- Oil & Gas 10%
- Water 9%
- Wastewater 8%

As shown above, 35% of Globe valves are used in oil & gas and chemical applications. Globe valves are used everywhere in the hydrocarbon value chain, especially upstream in reliability-critical applications, such as offshore rigs. Because the inner workings are protected, they provide good service in corrosive and high/low temperature environments, and also in high pressure environments where the internal 'z' pattern of fluid movement can help to constrict flow.

Cumulatively, global demand for Globe valves of the type in this study's scope increased by 0.5% in 2012.

In the oil and gas industry:

- Upstream, new rig additions to the global fleet declined as the orders that were NOT placed during the recession did NOT hit the market with the customary lag. Overall, 52 newbuild 'maxi' rigs entered the market in 2012, up from an estimated 35 at the beginning of the year,

giving Globe valve sales a boost. Furthermore, upstream gas processing facilities were more robust than upstream oil rigs, which further boosted demand for globe valves. The overall 'maxi' rig count dropped by 30 in the first quarter of 2013, but Globe valve sales will be more affected by new rigs entering than old rigs retiring.

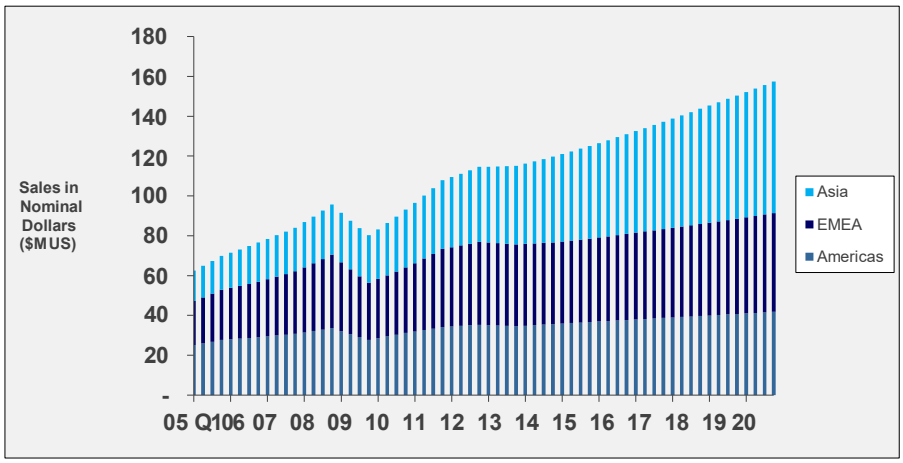
- Also upstream, BP signed a strategic (non-exclusive) supply agreement with Cameron for subsea production systems, including valves.
- Downstream, refinery capacity has increased by only 0.8% per year over the last three years, which was characterized by a slight downturn in 2012 and a large uptick this year. Therefore, orders for globe valve for downstream use has been muted.

Orders are growing particularly in the Middle East and Russia, two high-growth areas for oil and gas. As an example, Saudi Aramco signed an agreement with Samson that included globe valves. Samson also received orders from Russia, but declined to provide customer details.

Demand will grow 5.5% by 2015 and 32.6% by 2020, driven by growth in Africa and East Asia (all of Africa is classified within 'EMEA' in the chart below). Demand in these regions will increase by 2% and 1% per year, respectively, between 2010 and 2017. Correspondingly, demand will decrease by 2% and 3% in the NAFTA region and Western Europe over the same period, as underlying activity in process industries weakens there.

Some end-user industries are forecast to grow more than others, for example the metals and mining industries and the power industry are projected to grow at slightly over 30% over the next five years, versus about 28% for oil, gas, and petrochemicals.

Figure 11: Demand for Globe Valves



8.1.2 Supply (Capacity)

Cameron and Tyco expanded their facilities, assuring buyers of adequate supply for normal requirements. However, buyers should coordinate with suppliers in advance for orders over $4m to provide suppliers a long enough lead time to add or assign dedicated capacity.

The top globe valve manufacturers for engineered applications in the oil and gas industry are:

- Cameron
- Tyco/Pentair
- JC Valves
- Samson Controls
- FMC Technologies
- Valvitalia
- Flowserve
- Circor
- Crane
- Velan

Total industry capacity is $152 million per quarter, and rising $4-8 million per quarter as individual suppliers expand their plants or put up new ones (mostly in Asia). The globe valve plant expansions generally involve tens of thousands of square feet and/or tens of employees. For example:

- Cameron expanded its Dynatorque Flow Control plant in Muskegon, Michigan (US). No size was given, but a photo of the plant indicates that it is about a 25k square foot facility.
- Tyco Flow Control plans on a multi-million dollar investment to add a 33k square foot expansion and additional equipment to its 80k square foot facility in Harlingen, Texas. The expansion could bring the total investment in the Harlingen facility to nearly $20m.

Globe valve suppliers are 74% utilized, on average, based on an aggregation of specific globe valves suppliers' capacity utilization rates, as they apply to their globe valve production.

- Tyco, Flowserve, and Samson – three of the larger globe valve suppliers – are all only about 70% utilized. Tyco and Flowserve expect little change in their utilization rate (which is normal given their large size – it takes large capacity additions to affect the percentage very much), while Samson expects its capacity utilization rate to rise to 75% within a year, indicative of its growth ambitions.

- Velan, Crane, and MTS are 80% utilized, and Velan and Crane expect that to rise as their business continues to be strong. Velan's utilization rate is higher than many of its competitors because it is utilizing more of its capacity to execute a series of large orders. Crane and MTS are smaller suppliers of Globe valves (#9 and #11, according to our analysis), so follow demand rises with capacity additions rather than lead with them.

Total Globe valve capacity will rise by 2.8% in 2014, and will progressively increase during 2015-2020 to 4.5% to 4.8% in 2015 and 4.7-4.8% in 2016 through 2020. Capacity margin – the total amount of available capacity worldwide – will decline from $45m today to $35m in 2015 and stabilize through 2020. Given average orders of only $1-2m from large oil companies, that leaves adequate capacity for most orders. Anticipated requirements for more than $4m of globe valves should be planned with suppliers 24 months or more in advance to ensure adequate capacity.

Figure 12: Capacity Margin- Globe Valves

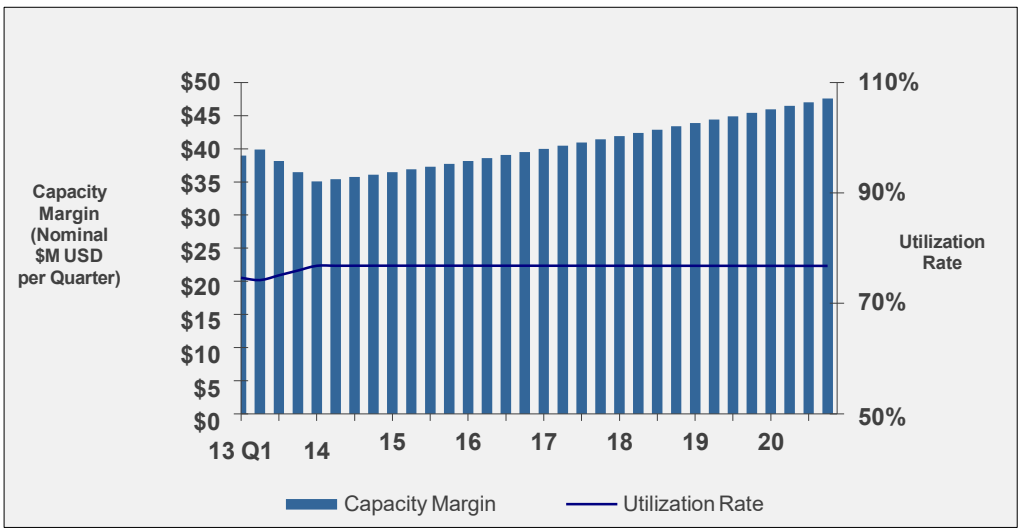
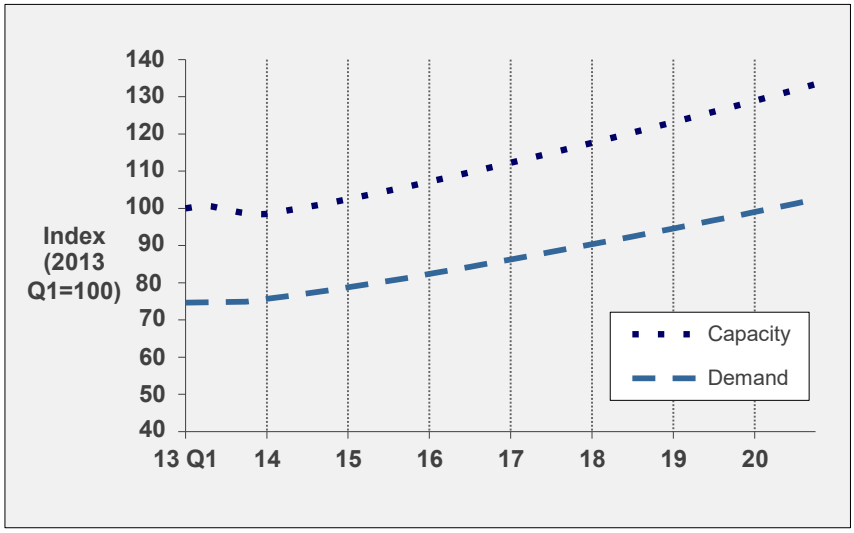


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Valvitalia	Italy	70%	70%
Valvitalia	China	70%	70%
Velan	Worldwide	80%	82%
Flowserve	Worldwide	70%	79%
Samson	Worldwide	70%	75%
Crane	Worldwide	80%	82%

Large oil companies such as Shell and Saudi Aramco, and large power companies such as China Nuclear (see below) are forming partnerships with globe valve manufacturers at the multi-product level to ensure stability of supply and prices. Overall, both demand and supply will increase steadily in line with 'growth pull' from the various valve-consuming industries, especially oil, gas, and petrochemicals.

Figure 13: Demand vs. Capacity - Globe Valves



8.1.3 New contracts

Velan scored big with globe valve contracts in China and India. The emerging nuclear power industry in Korea and China are contracting for ultra large valves.

Most globe valve contracts are part of larger agreements that cover multiple types of valves. Gate, Ball, and Globe valves tend to be contracted together in order to reduce contracting costs and increase economies of scale.

The largest recent globe valve contract was also a Gate valve contract. China Valves and CNPEC (China Nuclear) signed a $2m contract for gate, globe, & check valves at a likely 15-20% discount off of list price.

These are stemming from the emerging nuclear industry, especially in China. These contracts have a multi-year delivery schedule, so will continue to dominate the capacity of the concerned suppliers for at least the next two years.

The outlook for new contracts through 2015 and 2020 is stable. Quantitative forecast of new contract values over the time horizons. With Cameron, Tyco, and Samson actively having a demonstrated propensity to invest in capacity before demand rises, and smaller suppliers investing in capacity after demand has risen, aggregate capacity should remain adequate so long as demand growth remains steady.

Table 9: Summary of New Contracts and Estimated Values for Globe Valves

Buyer	Country of Installation	Supplier	Product	Estimated Value ($m)	Estimated Cost/Unit ($m) (Globe Valves)
China Nuclear Power Engineering Co. (CNPEC)	China	Velan	Gate and Globe	$61	$453
National Thermal Power Corporation	India	Velan	Globe and Gate	$20	$279
CNPE	China	Velan	Gate and Globe	$16.2	$453
Korea Hydro & Nuclear Power (KHNP)	Korea	Flowserve	Gate and Globe	$15	$638
Essar Oil Ltd.	India	CRI Pumps Pvt Ltd.	Gate and Globe	$1.9	$279
Saudi Aramco	Saudi Arabia	Flowserve	Control and Globe	10-year agreement	$744
SK E&C	South Korea	OMB	Gate and Globe	Unknown	$638
Saudi Aramco	Saudi Arabia	Samson	Globe	$2.5	$744
Mochovce Nuclear Power Plant	Slovakia	Velan	Gate and Globe	$19	$827
ABB	Africa	OMB Valves	Gate and Globe	Unknown	Unknown

8.2 Analysis

8.2.1 Costs

Globe valve prices rose by about 0.6% in 2012 as labor costs grew. Suppliers benefited marginally from falling metals prices.

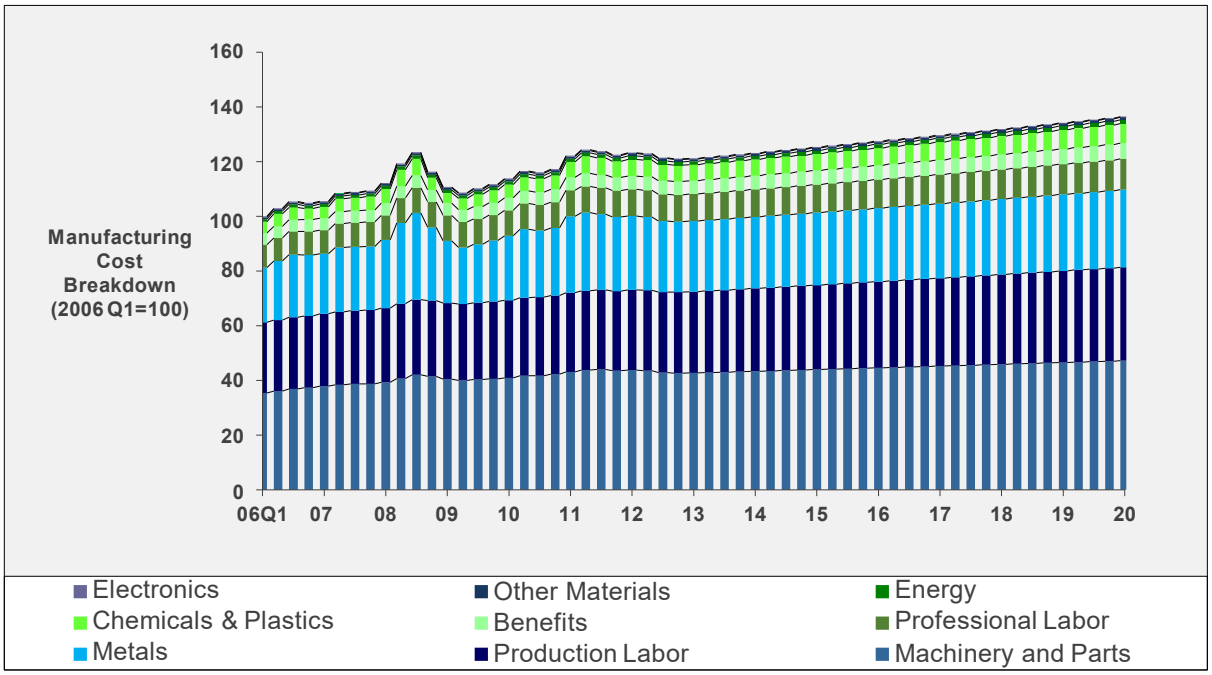
Overall, Globe valve prices rose by about 0.6% in 2012 on labor cost growth, despite slightly declining metal costs.

Labor and benefits together constitute slightly over 38% of the cost of Globe valves. At a global, level, both labor and benefits have been growing at 0.5% per quarter, or slightly over 2.5% per year.

The cost of the body, bonnet, and stem all fell in 2012 as metals prices fell on average.

- The price of a weighted basket of relevant metals, which comprise over 19% of the total cost of globe valves, fell by 8.4% in 2012, giving savvy buyers a lever for price reduction, and putting downward pressure on overall costs.
- Machinery and parts, which constitute about 23% of the total cost, also declined slightly in 2012 as falling metals costs factored into new machine tool costs.

Figure 14: Cost Structure of Globe Valves



Note: Prices are ex-works.

8.2.2 Profit Margins

Profit margins of globe valve suppliers are relatively thin. It is a commodity business and suppliers bundle globe valves with other types of equipment to enhance profitability.

A sampling of Globe valve suppliers realized a net profit margin of 5.4%. This is in the middle of the profit margins for manufacturers of other types of valves, such as Gate, Relief and Control. Given that it is a global business, profit margins are fairly uniform around the world. However, ultra large globe valves bring higher profit margins, so are preferred by suppliers.

No major supplier exclusively sells globe valves, so profit margins are inferred from those that sell a high dollar value and a high proportion of globe valves compared to their other valve products. Pentair, which sells both globe and relief valves, had a net profit margin of 1.0%. This may be unusually low in 2012 as a result of absorption of costs as a result of the Tyco/Pentair merger. Cameron, which sells globe and Gate valves, had a net profit margin of 7.5%. FMC, which sells control and globe valves, had a net profit margin of 7.8%.

We would expect profit margins to increase slightly (by about 2%) over the 2013-2015 period as capacity utilization rises.

8.2.3 Prices

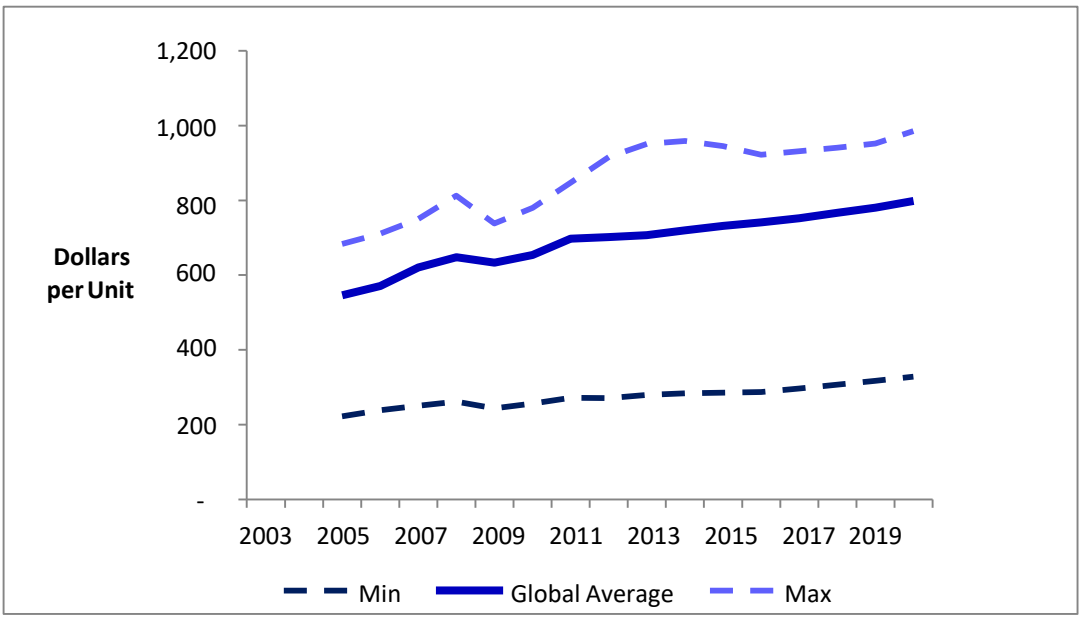
Steady, small escalation in prices of globe valves have become fairly predictable. India and China lead in low-cost (and low-priced) production.

Prices of Globe valves have been rising steadily, for a cumulative 0.7% in 2012. This rate of growth will increase in 2013 as capacity stretches thinner and suppliers take the opportunity to slightly raise prices.

This steady and predictable increase makes capital budgeting seem relatively simple. However, some buyers may recall the effect of the spike in steel prices from 2008. The risk of steel and/or labor cost spikes brings with it potential price increases and surcharges. Buyers who have formed multi-year agreements have based their annual price adjustment around pre-agreed cost indices that are prepared by the supply market intelligence group.

By 2020 prices will rise 13%, reflecting a 1.7% compound annual growth rate.

Figure 15: Overall Price Forecast for Globe Valves



Currently, India is the least expensive production base for Globe valves, and Japan is the most expensive.

- Actual bids from China (15 of them) averaged $464 per globe valve for small orders.
- The Indian price for the same valve would be $279, based on our analysis.
- The comparable actual price from Russia is $785, which is only $37 lower than the US price.
- Japan's cost of manufacturing is over $900, based primarily on high costs for power and labor.
- Latin American and African prices are slightly (about 10%) lower than those in the US and Japan. African globe valves are typically industrial rather than petroleum grade.

By 2020, India and China will still be the least expensive locations to produce Globe valves. Russia will become relatively more expensive than it is today, as the cost of engineering labor, metals, and industrial production rises by 4-8% per year on a sustained basis.

Countries with higher prices lowered them to the world average during the 2008-09 recession (see chart of max vs. global average prices), but are widening the gap again as that event recedes from memory.

Table 10: Regional Price Variations over Time for Globe Valves

Region/Country	Today	2014	2015	2020
North America	1.00	1.02	1.00	1.05
Latin America	0.89	0.93	0.95	1.14
Europe	1.01	1.02	1.01	1.07
Africa	0.90	0.94	0.93	1.03
India	0.34	0.35	0.35	0.40
Russia	0.96	0.99	1.01	1.20
China	0.55	0.55	0.55	0.58
Japan	1.16	1.17	1.15	1.17
Other Asia	0.78	0.75	0.71	0.69

8.2.4 Price Differences by Technology, Model, and Feature

Size, material, and pressure class drive price differences among globe valves. When based on a 6" diameter API 600 or 602 carbon steel globe valve of 150 pressure class, with SS 316 trim, maximum working temp: 800°F::

- Increasing the diameter increases the price of a globe valve by $330 per inch.
- Upgrading to stainless steel 316 increases the cost by 2.99 times.
- Upgrading to stainless steel 317L increases the cost by 4.62 times.
- Increasing the pressure class costs $4.86 per pressure class increment (of 1).

Table 11: Incremental Cost per Extra Parameter or Feature for Globe Valves (relative to a unit of carbon steel, 150 pressure class)

Parameter or Feature	Unit of Measure	Indicative Cost Impact	Notes / Comments
Size	Diameter (inches)	$330/inch	Cost grows exponentially with size
Material	Carbon steel as reference point	2.99x for stainless steel 316	4.62x for Stainless 317L
Pressure Class	150, 300, 600, 900, 1500	+ $4.86 per incremental pressure class rating (of 1)	Cost grows exponentially with pressure class

Note: Changing one parameter usually involves changing others, and the cost impact may not be additive or linear.

The cost of an extra inch in diameter increases the price of the valve disproportionately, until 10". Starting at a 10" diameter and up, the relative benefit cost per inch of diameter increases at a decreasing rate.

Figure 16: Globe Valve size vs. Cost – by Pressure Class

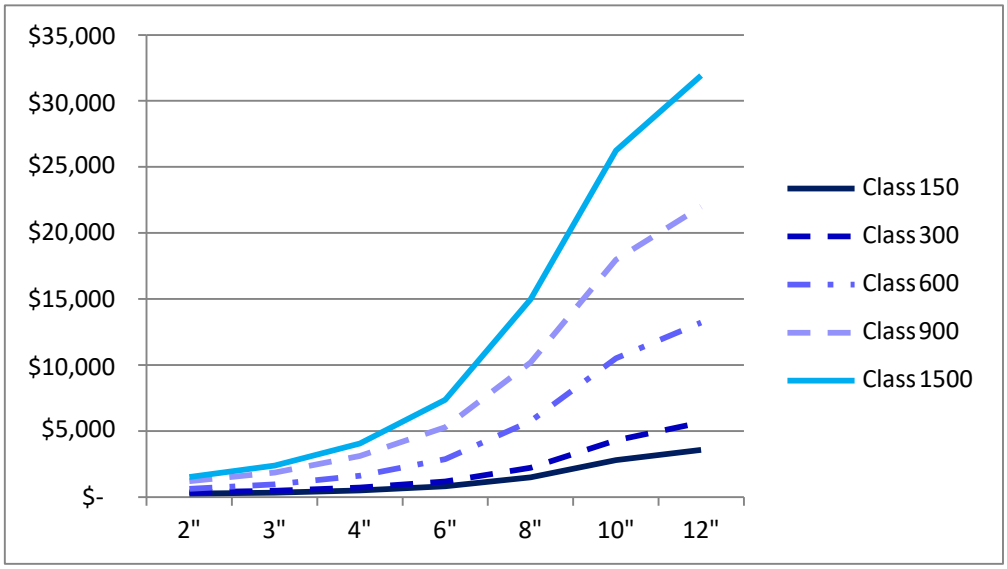
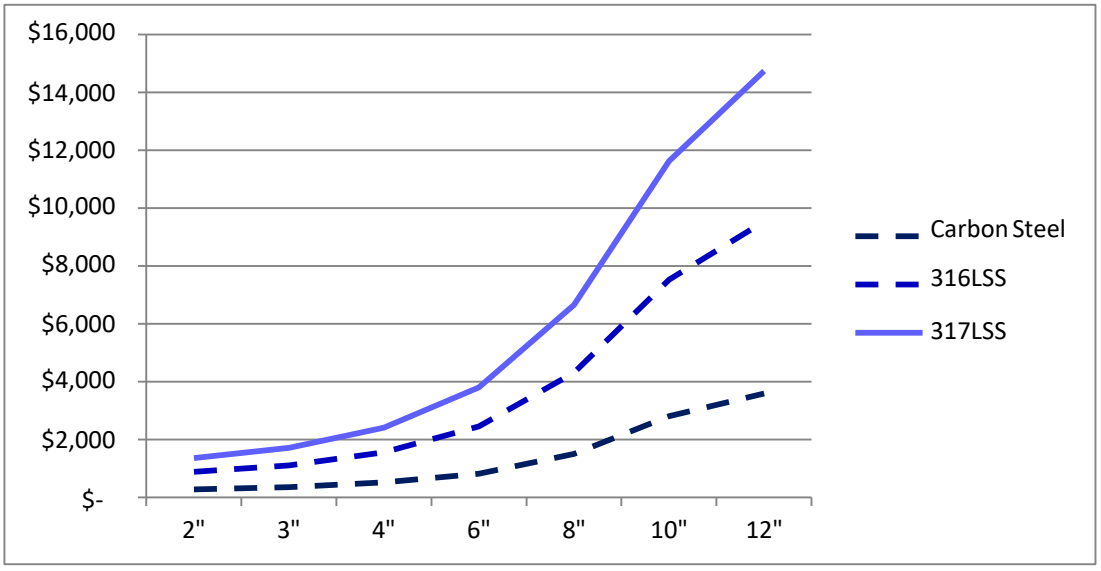


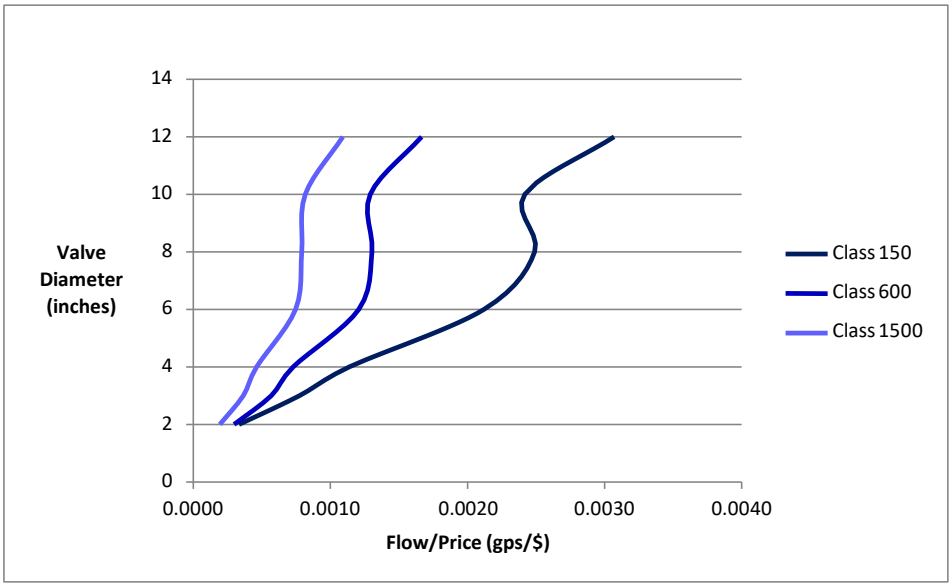
Figure 17: Globe Valve size vs. Cost – by Material (Class 150)



For each additional 10 inches of diameter, the output flow for each extra dollar spent increases by 0.0010 to 0.0030 gallons per second.

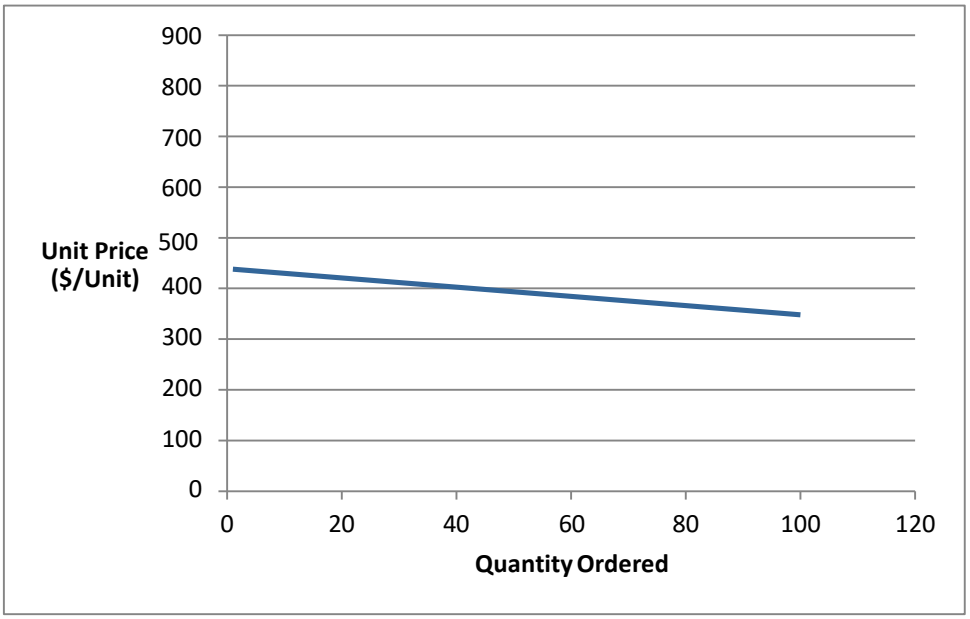
The increase in size offers valuable benefits, however. For Globe valves, each inch increase in diameter yields more flow. The cost/benefit ratio improves as the diameter increases, up until 8". For example, an investment in a 8" valve is expensive, but it generates a proportionally much higher incremental increase in flow than moving a 3" or 4" Globe valve. Beyond 8" in diameter, the relationship becomes more linear, and can actually degrade between 8" and 10".

Figure 18: Output Flow for Each Extra Dollar Spent vs. Globe Valve Size – by Pressure Class



An analysis of 17 actual bids of varying quantities indicates that there are extraordinary economies of scale in purchasing globe valves. Based on this sample, for every additional 100 units ordered, the unit price decreases by 21%. However, the dispersion of data around the mean error is wide and broad, and statistically not reliable. It is clear nonetheless from our experience, that suppliers are eager to capture large orders and will give price concessions to win the business from competitors.

Figure 19: Economies of Scale in Globe Valves



8.2.5 Should-Cost Analysis

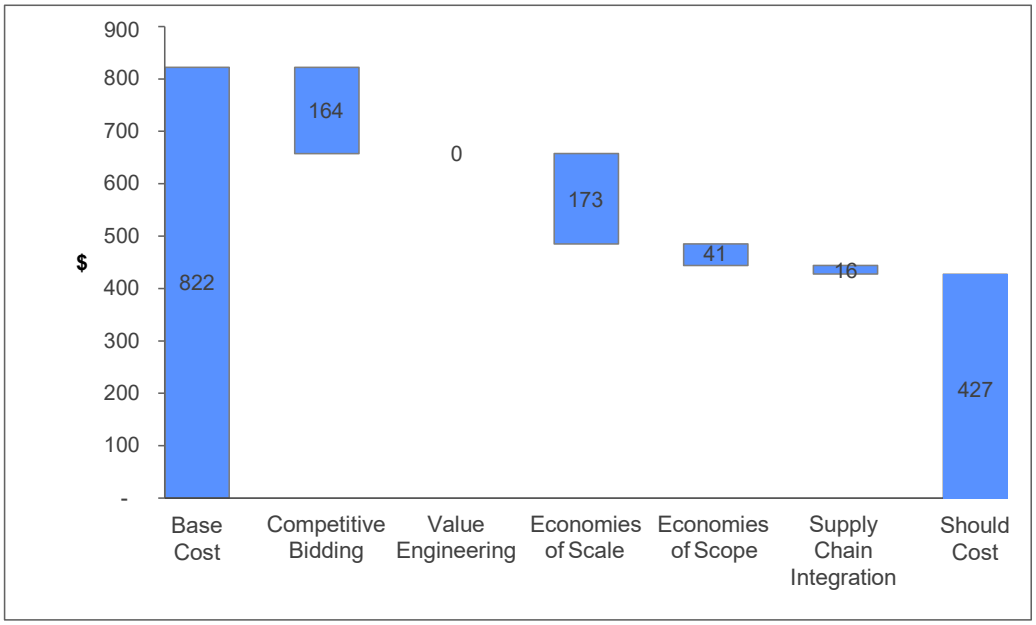
Competitive leverage should allow any major oil company to achieve 20-25% off of the list price of globe valves. Buyers like China Nuclear (CNPEC) and Essar Oil have achieved 20-25% reduction off of the list price from China Valves and CRI Valves, respectively. Shell probably received more than a 25% discount on its 5-year agreement with Flowserve.

Assuming that the suppliers offer a 20% discount due to competitive pressure, buyers should look for an additional 2.9% reduction in price for every 100 Globe valves ordered, due to economies of scale.

In addition, by combining the purchase of globe valves with other products, such as pumps, piping, flanges, or fittings, buyers can expect 5% more from economies of scope.

Finally, since many valves are a stocked item, buyers can and should expect suppliers to hold inventory for them. This can save an additional 1-2% per year in stocking costs.

Figure 20: Should-Cost for Globe Valves



8.3 Price Negotiation Strategies

1. Engage at least three low-cost country suppliers to augment price competition. India, China, and other Asian countries are high-potential areas to look for lower-cost suppliers.
2. Negotiate on the basis of five years of requirements to maximize economies of scale.
3. Bundle purchases of globe valves with other valves, and with related products, to achieve economies of scope.
4. Request suppliers to hold and maintain your inventory for you (vendor management inventory, or VMI) to save on stocking costs and the associated overhead costs.

9 Relief Valves

9.1 Market Overview

Table 12: Key Indicators for Relief Valves
(Total Change over Each Period)

Key Indicators	Q1 2013 – Q1 2015		Q1 2013 – Q1 2020	
Demand Growth	▲	5.5%	▲	35.4%
Demand ($m)	▲	121-128	▲	121-164
Capacity Utilization	▲	0.9%	▲	0.9%
Prices	▲	3.0%	▲	12.8%

9.1.1 Demand

The decline in oil prices in 2010 and 2011 has created a 'whipsaw' effect in demand for relief valves. Sales, which boomed in 2012, will hold relatively steady this year before resuming strong growth in 2014 through 2020.

Relief valves comprise only 4% of all valve sales to all industries. However, they are mission-critical, so they are a much more significant part of oil and gas procurement activity than the percentage would indicate.

As with globe valves, over a third of relief valves are purchased by the oil, gas, and chemical industries (37%, compared to 35% for globe valves). Other major sales go to the power, iron and steel, and pulp and paper businesses, which are also process intensive and involve boilers and/or process fluids. The split of sales to these industries tends to be very stable over time. We focus here on demand coming from:

- Chemicals
- Coke & refined petroleum products
- Oil & gas extraction
- Industrial production, including construction
- Utilities

Relief valves are used in many refinery applications including, for example:

- Critical and subcritical gas pressure relief, including flaring
- Steam boil-off
- BTEX (benzene, toluene, ethylbenzene, and xylenes) and glycol reboiler safety relief
- Pressure relief from tank filling and emptying, including tank blanketing

- Relief of vacuum pressure
- Gas pressure relief

Refinery capital construction stagnated in 2010 and grew only slightly in 2011. American and European oil companies closed refineries in 2010 and 2011. Refiners released pent-up demand in 2012 by ordering almost 6% more relief valves than in 2012. As a result of last year's surge, we expect to see a lull to 0.8% this year (2013) before a return to consistent, strong growth.

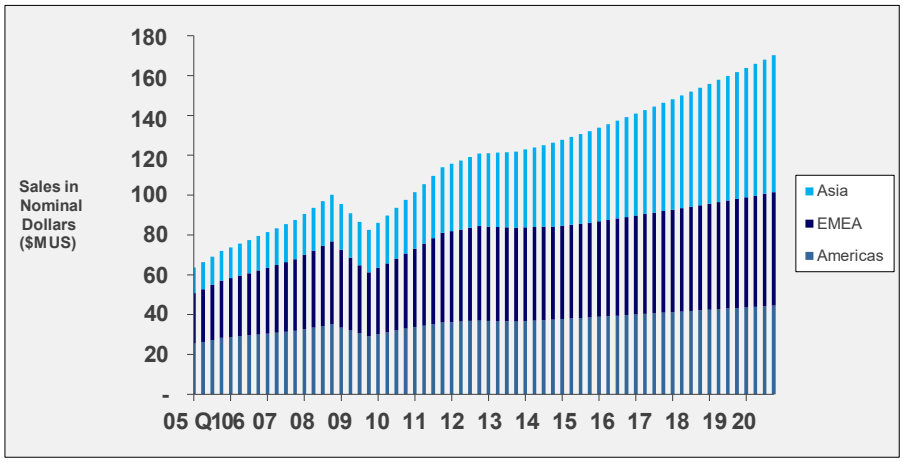
Within the oil, gas, and power industries, recent industry activity is marked by an increase in specially-designed valves for gas processing and transmission, as well as downhole units for oil production.

- For upstream gas processing, McKenzie makes custom overpressure relief valves for compressor stations, gas pipelines and storage systems, and gas processing plants. Also, Taylor Valves (Oklahoma, US) makes engineered valve solutions such as pump bypass, pump relief, well hookups, closed loop systems for high pressure relief applications, and leak detection in CNG applications. The applications it serves include air, gas, or liquid relief for compressors, separators, heater treaters, free water knockouts, scrubbers, dehydrators, thermal relief, gas production units, chemical plants, refineries, gas, plants and other industrial applications.
- For downhole oilwell valves, Halliburton (US) makes tubing-retrievable and wireline-retrievable safety valves, including both surface-controlled and direct-controlled designs. It also makes a CV0 Retrievable Straddle with Integral Safety Valve (intervention solution).
- Nuclear valve applications are robust in China and Korea (but the fallout of the Japanese disaster has stymied expansion in the EU and North America).

Overall global demand for Relief valves will grow at least 9% between 2013 Q1 and 2015 Q4. Demand in 2014 and beyond will be supported by orders from the upstream oil and gas industry and the return of capital expenditure in the refinery sector in 2014 and 2015. Stronger than expected demand growth could bring the total demand increase over the same period to 13.7%.

Longer term, by 2020, demand will increase by 35.4%, reflecting an underlying compound annual growth of 4.4% year on year.

Figure 21: Demand for Relief Valves



9.1.2 Supply (Capacity)

Suppliers such as GE and Valvitalia are reconfiguring capacity to respond specifically to growing demand in the oil and gas sector. Suppliers are operating at 70-80% of capacity, but the total amount of capacity available is low, so buyers running large capital programs would be wise to plan Relief valve capacity with suppliers in advance.

The top relief valve manufacturers for oil and gas applications are:

- Circor
- Tyco/Pentair
- GE
- Cameron
- ITT (Dresser)
- FMC Technologies
- Halliburton
- Taylor Valves
- Mckenzie Corp.

Aggregate capacity for Relief valves is $160m per calendar quarter. Since suppliers are operating at an average of approximately 75% utilization, there is $40m of available capacity per quarter to serve major capital projects. While the total amount of available capacity is expected to remain stable, capacity margin is very thin. Large orders for specialized valves can rapidly eliminate available capacity for individual companies. If individual oil companies negotiate capacity commitments with the major valve suppliers that control almost 90% of available capacity (Circor,

Tyco/Pentair, GE, Cameron, ITT (Dresser), and FMC Technologies), capacity margin could shrink to extremely low levels. In such a case, lead times would extend and prices would spike.

More relief valve suppliers are opting to specialize in oil and gas applications due to the growing market. For example, Mercer Valves, an $11m North American and Australian relief valve manufacturer, makes snap pilot valves exclusively for oil and gas applications. At the same time, software vendors and third parties are developing applications designed to manage pressure in oil and gas processing systems. For example, Berwanger et al. patented a relief system algorithm that minimizes pressure across an entire system rather than at specific points through safety relief valves. The result, as practiced, would be an intelligent hybrid relief and control valve system.

Although not capacity additions per se, the last several years have seen significant reconfigurations of global capacity in the relief valves market.

- GE bought Dresser in 2010 for $3b, adding oil and gas valves to its portfolio and enabling it to compete with Tyco/Pentair, Flowserve, and Emerson Process Control. Given that Tyco is one of the top two relief valve manufacturers, and Emerson Process Control is by far the largest control valve supplier, the move elevated GE to the number three slot in relief valves.
- Valvitalia's acquisition of Broady Flow Control (2010) created a stronger supplier in safety relief valves. Broady has specific experience in valves for sour gas service to NACE MR-01-75. Broady's non-ferrous foundry produces castings in aluminium, bronze, gunmetal, aluminum, and monel.
- Emerson is explicitly focusing on aligning its capacity and value proposition around intelligent multi-category intelligent technology based systems that tie valves together and add decision making capability.

Some suppliers added capacity outright. For example, Halliburton opened two manufacturing facilities for downhole tools that will make a variety of downhole tools and intelligent completion components, which include downhole control valves. In August of 2012 it opened a facility in Lafayette, Louisiana (US). Then it opened a Completion Technology and Manufacturing Center in Singapore in March 2013.

Most Relief valve suppliers are 70-80% busy. This market segment requires a lower capacity utilization than for a commodity product (say, ball valves or Gate valves) due to the specialized nature of the manufacturing operation, which requires a larger buffer of available time and resources to accommodate specific new orders. On an adjusted basis, the safety relief valve suppliers are therefore about as busy as the Gate and globe valve manufacturers.

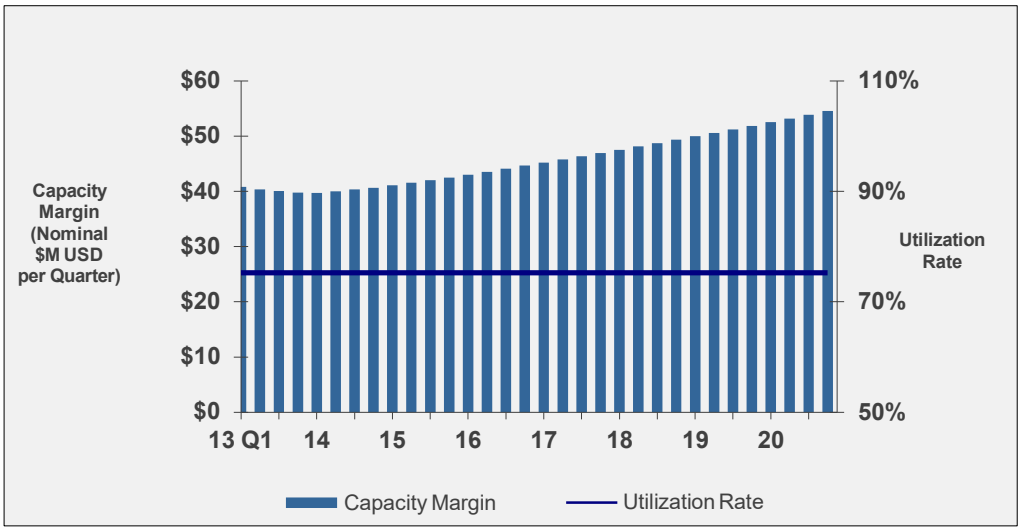
Pentair is operating at about 80%, while Tyco and Valvitalia are operating at about 70% of their total capacity. Valvitalia and Tyco's relatively lower capacity utilization rates may offer buyers an opportunity to obtain lower prices. Tyco has a new plant in the UAE that is not yet filled, and until it is operating above its breakeven point Tyco would be rational to offer every incremental order at its marginal cost of production rather than its fully loaded cost. This could result in about a 20% discount. Also, Valvitalia is operating in the stagnant European market, and might offer price concessions in exchange for large orders in fast-growing emerging economies.

Table 13: Reported or Estimated Capacity Utilization Rates at Selected Relief Valve Suppliers

Company	Country	Current Level	12-Month Forecast
Pentair	China	80%	80%
Pentair	India	80%	80%
Pentair	USA	80%	80%
Pentair	Australia	80%	80%
Tyco	UAE	70%	70%
Tyco	Worldwide	75%	75%
Valvitalia	Italy	70%	70%
Valvitalia	China	70%	70%

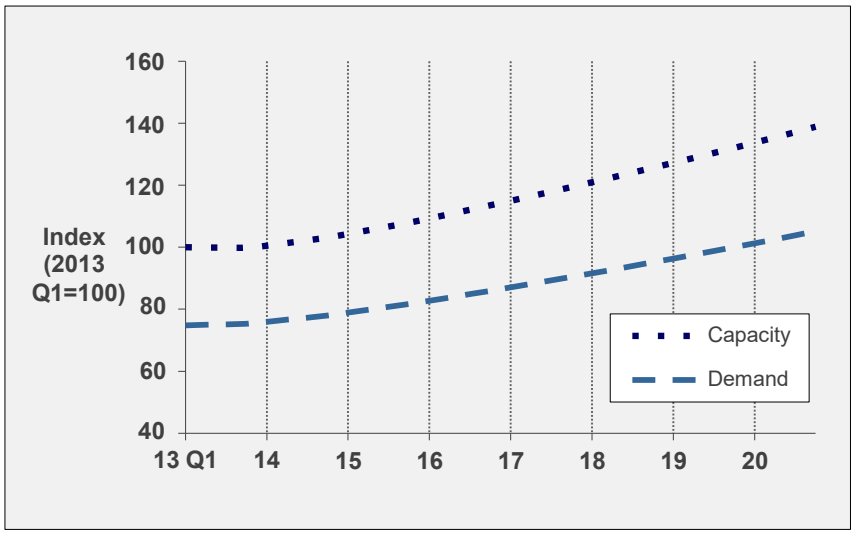
We forecast that capacity utilization for Relief valve suppliers will remain constant at slightly over 75% through 2020, based on improving business conditions in the Relief valve market, executed by a shift of manufacturing capacity from non-oil and gas sectors to oil and gas applications, and an increasing specialization of relief valve suppliers in the energy industry. Thus, while overall industry capacity may not increase, the capacity for oil and gas applications will, as a share of the total.

Figure 22: Capacity Margin – Relief Valves



Overall, supply will keep pace with a rising demand, and both will increase through 2020.

Figure 23: Demand vs. Capacity - Relief Valves



9.1.3 New contracts

Safety valves for the nuclear industry are getting major suppliers' attention.

Substantial activity is coming from the nuclear power industry. For example:

- China's State Nuclear Power Engineering Co. (SNPEC) awarded Tyco/Pentair two relief valve contracts for four Westinghouse AP1000 units currently under construction. Tyco will supply the main steam safety valves and pressurizer safety valves for two reactors at Sanmen in Zhejiang province and two at Haiyang in Shandong province. The valves will be delivered in 2013 and 2014, according to the production schedule of the two plants.
- The Barakah nuclear plant, to be built in the United Arab Emirates, awarded Pentair a contract for four of its Sempell pilot-operated pressurizer safety relief valve (PSRV) systems. Doosan Heavy Industries, one of the subcontractors used by Korea Electric Power Cooperation to supply turbines and generators to the project, specified Sempell PSRV systems for use in the pressurized water reactors (PWR). Pentair had invested four years in research and development on the customized safety valves.
- China's SUFA Technology Industry Co Ltd - a subsidiary of China National Nuclear Corp, in conjunction with the largest valve manufacturer in China, awarded Flowserve, its joint venture partner, a contract to produce safety valves, including Main Steam Isolation Valves (MSIVs), exclusively for China's nuclear power industry. The joint venture - Flowserve-SUFA Nuclear Power Equipment Co. Ltd - will be based in Suzhou (Jiangsu province), and will be 51% owned by SUFA and 49% by Flowserve.

Major oil and gas producers are locking in framework agreements for complex relief valves to assure supply for their upcoming capital expansion programs. For example:

- Saudi Aramco signed a $250m agreement with GE in October 2012 that included many aspects of cooperation on a local service facility. Among the many platforms for growth in the Kingdom, GE is pledging to open a 'pressure control facility' that will manufacture wellheads and valves that support the upstream oil and gas sector. The facility is API and ISO certified, and employs over 75 Saudis to help the Saudi government meet its Saudization objectives. To be clear, the $250m figure refers to capital investment rather than a valves contract.
- Shell awarded Tyco Flow Control a framework agreement for pressure relief valves and after-market services for direct acting and pilot-operated pressure relief valves.

Many new contracts were signed, for example:

- Southern Company's Mississippi Power Integrated Combined Cycle (IGCC) power plant in Kemper County, Mississippi (US) ordered more than 50 separate turbine and process steam bypass valves, spray water control valves, pressure reducing valves and silencers from GE. GE will provide its Masoneilan* LincolnLog* and SteamForm* modulating steam control valves and auxiliary systems. The Masoneilan bypass valves will "facilitate the startup, shut-down and trip cycles of the steam turbines as well as provide process steam to and from the gasifier, and are necessary for the flexible operation of the plant in response to fluctuating power demand," according to GE.
- The Brazilian processing plant consortium Conpar engaged Dresser (now GE) in a $5m contract for 160 control and 90 relief valves, According to our sources, the price of the relief valves in the package was approximately $19k each.

Specialized valves for downhole directional drilling are becoming a larger market.

- Halliburton signed many agreements. While valves are too small a line item to be called out separately in these agreements, Halliburton's scope is likely to include relief valves.
- Italian oil company Eni contracted with Halliburton to help develop 20 oil wells in the Zubair field in southern Iraq. (August 2010)
- Malaysian oil company Dialog signed a $1.2 billion contract with Halliburton to help it with enhanced oil recovery efforts. (November 2012)
- Salym Oil Fields (Western Siberia) extended its contract with Halliburton for horizontal drilling for another four years. This will inevitably consume some number of relief valves, mostly for downhole applications.
- ExxonMobil hired Halliburton to drill 15 more wells in Southern Iraq.(April 2011)

We believe that the outlook for more such framework agreements and nuclear contracts is robust, especially in Asia. Saudi Aramco and Shell are just two of a number of leaders in the oil and gas industry who will follow suit with similar agreements. Also, the burgeoning nuclear industry, after suffering a setback after the Japanese tsunami disaster in 2010, seems to have regained momentum and there are plans in the Middle East as well as Korea and China, where most of the recent contracts have been signed.

Table 14: Summary of New Contracts and Estimated Values for Relief Valves

Buyer	Country of Installation	Supplier	Product	# of Units ($m)	Estimated Cost/Unit ($m)
Conpar	Brazil	Dresser	Relief	240 units	$13.6
Braskem (via Yokogawa)	Brazil	Dresser	Relief	90 relief, 160 control	$19k
Athabasca Oil Sands	Canada	Dresser	Relief	N/A	$15.1
Southern Company	US	GE	Relief	N/A	$15.1
State Nuclear Power Engineering Co (SNPEC)	China	Tyco (Pentair)	Relief	N/A	$9.6
Barakah Nuclear Plant (via Doosan)	UAE	Tyco (Pentair)	Relief	N/A	$14.4
SUFA Technology (a subsidiary of (CNNC)	China	Tyco (Pentair)	Relief	N/A	$9.6
Shell	Global	Tyco	Relief	N/A	$7.6
Saudi Aramco	Saudi Arabia	GE	Relief	N/A	$14.4
Various	Iraq, Malaysia, and China	Halliburton	Downhole Safety	N/A	N/A

9.2 Analysis

9.2.1 Costs

Costs for relief valves increased fractionally in 2012, and appear poised for 1.4% to 2% increases through 2020.

Globally, costs for Relief valves declined by 0.7% in 2012, as metals and machine tool costs declined, and labor costs held steady.

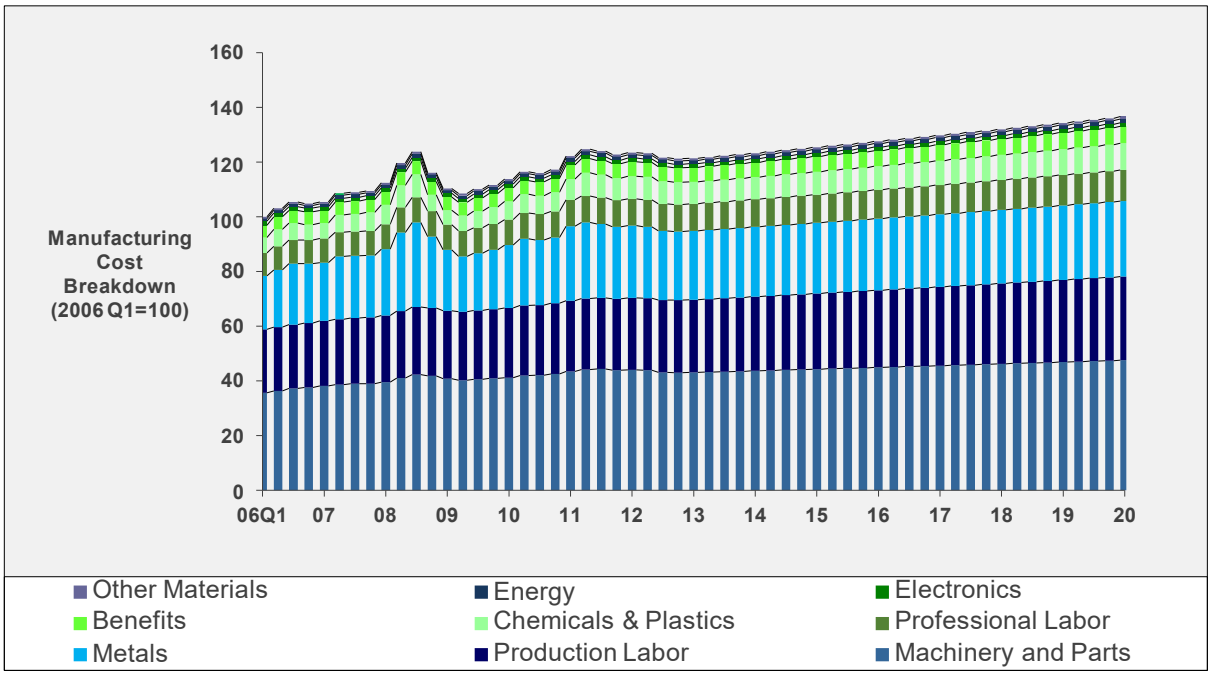
Metals and machine tool costs both dropped by about 1% throughout 2012. Machine tools have completely moved from the US, and mostly from Europe, to Asia, taking advantage of lower labor costs.

Labor costs, which make up about 32% of the total cost of relief valves, only increased fractionally (less than half a percent) in 2012. This reflects not wage shrinkage, but rather a shift from relatively expensive Western economies to relatively less expensive sources in emerging economies.

The cost of chemicals, plastics, and miscellaneous components increased, but as these comprise a small percent of the total cost, this did not affect the total cost structure of relief valves.

In aggregate, the factor input costs for Relief valves will increase by 1.4% to 2.0% over the foreseeable time horizon.

Figure 24: Cost Structure of Relief Valves



Note: Prices are ex-works.

9.2.2 Profit Margins

Margins are low and costs are declining, putting buyers in a position to exert downward pressure on prices and force suppliers to restructure and offshore to lower-cost production bases.

Manufacturers that make a large proportion of relief valves as compared to other valves have an average of 4.0% net profit margin and 10% operating profit margin.

- Pentair (Tyco's Flow Control unit) earned only 4% operating profit and 1% net profit.
- Circor's energy business segment earned 6.9% operating profit and 4.5% net profit.
- GE's Oil & Gas segment earned 25% operating profit and 9.6% net profit.

These are lower percentages than for any other valve type in this study, reflective of the competitive intensity caused by a shift of manufacturing to Asia. Although there are many applications of relief valves at the premium end of the spectrum, there are enough simple carbon steel, mechanically actuated safety relief valves to create ' price drag' on the industry as a whole.

We expect margins to remain low, given industry dynamics. While prices are relatively stable (they bounce around within about a 1% band), lead time is projected to decline slightly and capacity utilization will remain flat. With these fundamentals, we see an opportunity for buyers to exert competitive pressure to drive prices down.

9.2.3 Prices

After some bumpiness, Relief valve prices have stabilized and are poised to grow at 1.4-1.7% per year through 2020.

Historically, Relief valve prices have swung between 1 and 5% inflation per year, with one negative year in 2009 on the heels of the global recession.

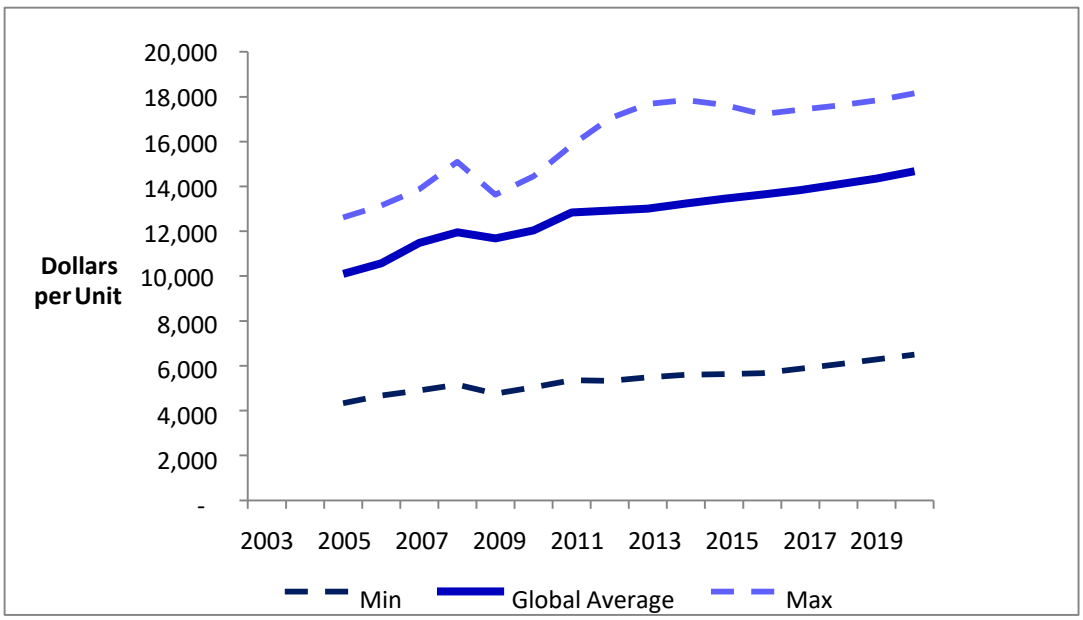
After rising 5.3% and 3.8% in 2010 and 2011, respectively, Relief valve prices rose by less than 1% in 2012 on a pause in refinery demand.

Prices should rise 3% by 2015 Q4 – less than general inflation, due to excess manufacturing capacity that has created a highly competitive market that buyers can 'play.'

Longer term, prices will rise 13% by 2020, reflecting a compound annual growth of 1.7%, with a progressive increase from a 1.4% annual rate upwards to 1.7% over the period.

Overall, the outlook is currently for long-term stability, which augurs well for partnering and long-term relationships with core suppliers.

Figure 25: Overall Price Forecast for Relief Valves



Regionally, prices vary widely – from 64% below the mean to 17% above it.

The US benchmark price for the reference relief valve is $15,132, based on the a reference valve of 6" diameter carbon steel, API 520 and 521, pressure class 300, and maximum working temp: 800° F.

European, Middle Eastern, Russian, and Latin American prices are either on par with, or slightly lower than, US prices. We estimate that Brazilian Conpar paid GE/Dresser about $14,000 per relief valve in the aforementioned contract. Our calculated price for Africa (typically imported product) is $14,417, approximately the same as the price in Russia.

Chinese prices for relief valves are 37% lower than the comparable US prices.

The least expensive sourcing location is India, followed by China, for which we have a bid for $11,524 and we believe that the price would be negotiable to $9,000 to $9,500.

Japanese prices are on the high end of the scale due to high labor and electricity costs.

Table 15: Regional Price Variations over Time for Relief Valves

Region/Country	Today	2014	2015	2020
North America	1.00	1.02	1.00	1.06
Latin America	0.90	0.94	0.96	1.17
Europe	1.02	1.03	1.02	1.09
Africa	0.95	0.94	0.93	1.03
India	0.36	0.37	0.37	0.43
Russia	0.95	0.99	1.01	1.20
China	0.63	0.64	0.63	0.68
Japan	1.17	1.18	1.17	1.19
Other Asia	0.78	0.79	0.79	0.83

9.2.4 Price Differences by Technology, Model, and Feature

Once the basic specification is determined, size, material, and pressure class are significant variations that can dramatically change the base price of simple, carbon steel relief valves.

Starting with a simple carbon steel relief valve of 150 pressure class:

- Each extra inch of diameter costs $3819more.
- 316 Stainless steel costs 1.64 times more.
- Each incremental digit of pressure class rating adds $17.4 to the cost of the valve (assuming theoretically that one could specify pressure classes to the single digit).

Table 16: Incremental Cost per Extra Parameter or Feature (Indicative) for Relief Valves (based on a carbon steel unit of 6" diameter, Pressure class: 300; Max working temp: 800° F; API 520 and 521)

Parameter or Feature	Unit of Measure	Indicative Cost Impact	Notes / Comments
Size	Diameter (inches)	$3819/inch (based on carbon steel)	Cost grows faster with size after 6" diameter
Material	Carbon steel as reference point	1.64x for stainless steel 316	317L not ordinarily ordered
Pressure Class	150, 300, 600	+ $17.4 per incremental digit of pressure class rating	Cost grows exponentially with pressure class

Note: Changing one parameter usually involves changing others, and the cost impact may not be additive or linear.

The relationship between size and cost changes after 6" diameter – each extra inch after 6" costs disproportionately more than with smaller relief valves.

Figure 26: Relief Valve Size vs. Cost – by Pressure Class

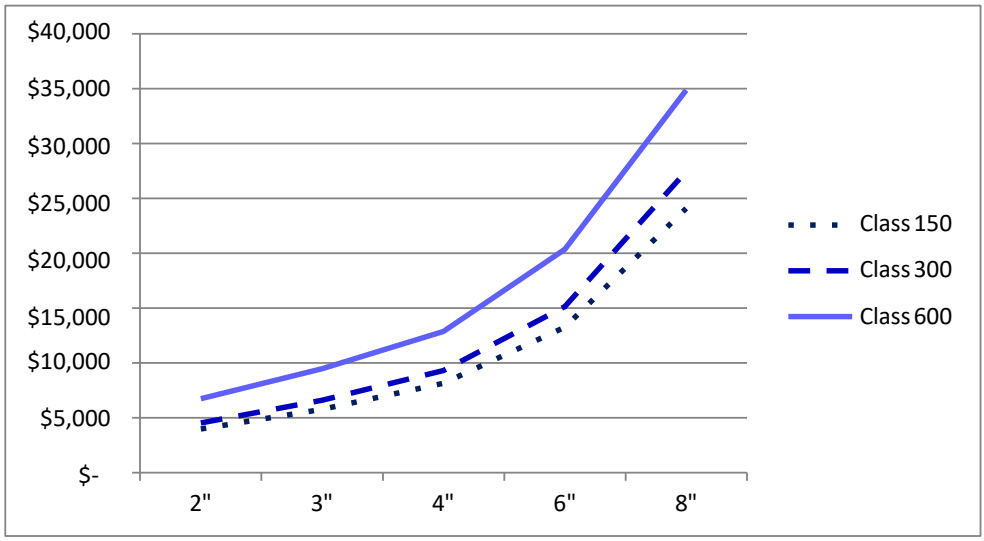
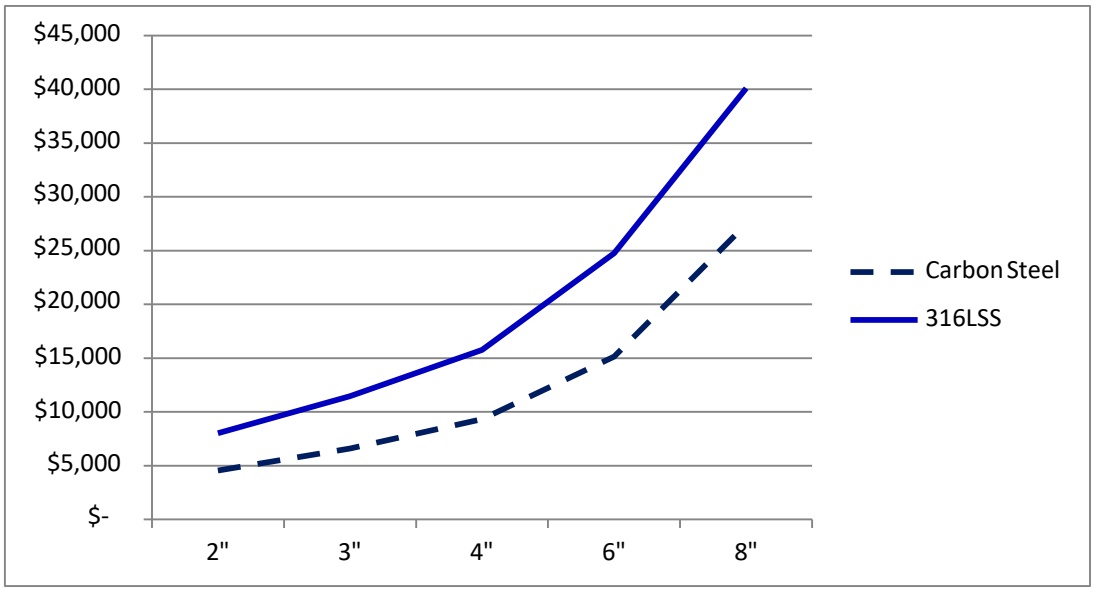
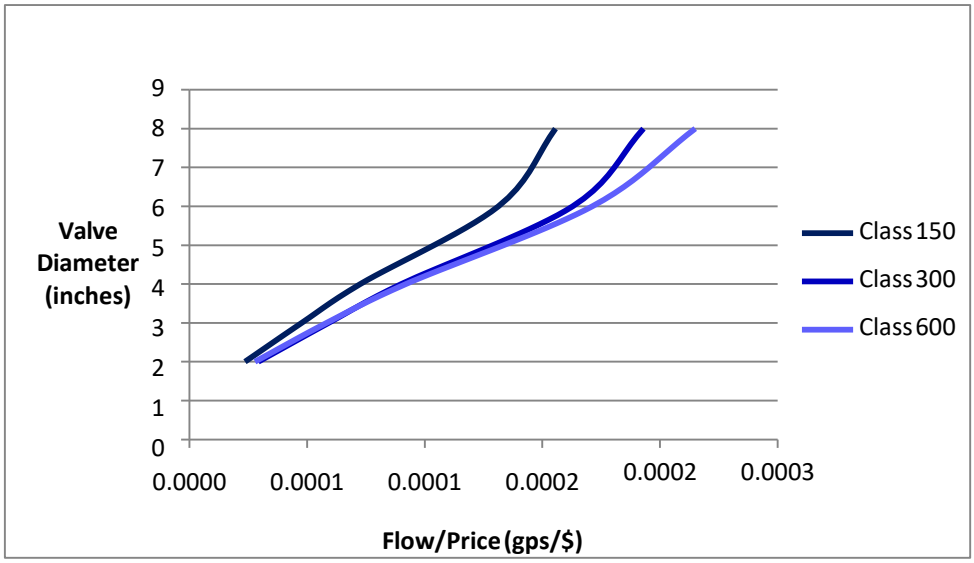


Figure 27: Relief Valve Size vs. Cost – by Material (Class 300)



Although increases in size cost more money, they achieve a higher flow rate, which has valuable benefits. For relief valves, each inch increase in diameter yields more flow. If the engineering specifications offered any choice in the matter, the cost/benefit ratio of diameter to value of the flow rate improves after about 6" in diameter, and also disproportionately with pressure class.

Figure 28: Output Flow for Each Extra Dollar Spent vs. Relief Valve size – by Pressure Class



A series of bids reveals even stronger economies of scale than with Gate or globe valves. This relationship would likely yield decreasing marginal returns at some point on an extended curve (e.g., 200-500 units per order).

Figure 29: Economies of Scale in Relief Valves



9.2.5 Should-Cost Analysis

Buyers have used economies of scale and competitive bidding to achieve lower-than-market prices.

- Conpar ordered 90 or more relief valves at a time, and according to our analysis they have achieved over 20% savings from published pricing on the unit price of the lot by doing so.
- Shell used price leverage while formulating its negotiating position for its Enterprise Framework Agreement with Tyco. Shell has a formal core supplier program, for which it deliberately aggregates volume in exchange for lower prices with its core suppliers in many categories.

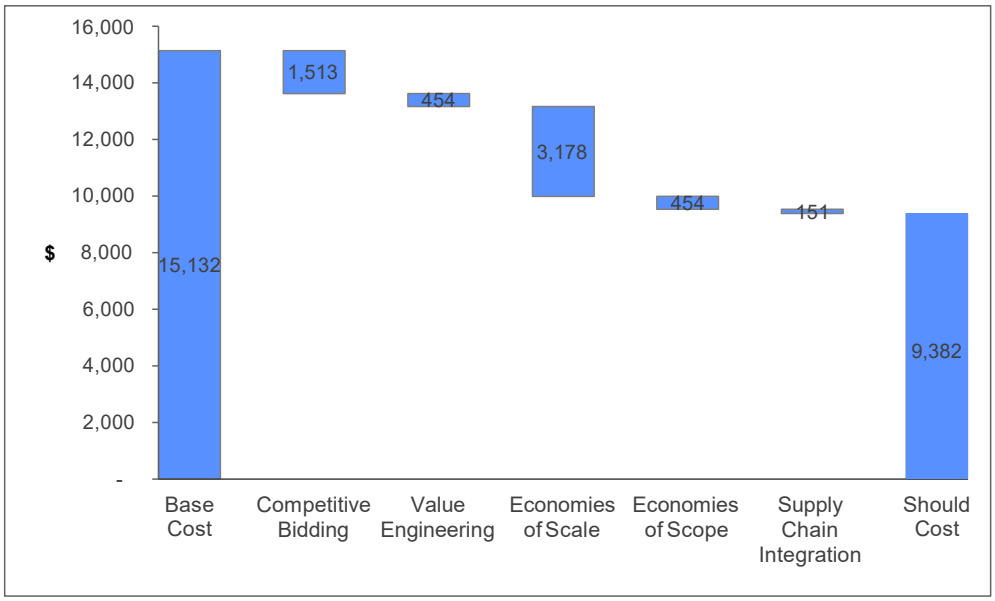
In addition, others have used value engineering to achieve further savings.

- At a simple level, downgrading from a higher to a lower pressure class, or from stainless steel to carbon steel, or from a larger size to a lower size, can all reduce unit cost. This requires fully understanding the required capacities and performance of each valve application.
- At a more complex level, users may achieve lower total cost by custom engineering a solution. The Barakah nuclear plant, to be built in the United Arab Emirates, asked Pentair to design a custom safety valve, presumably because it would have a lower total lifecycle cost than the standard valves that were available to it. The customization was worth four years of investment, which indicates that there were large savings to be had.

Economies of scale can also reduce cost. Referring once again to the aforementioned example of Conpar, Conpar ordered 250 valves at the same time. Of the 250, 90 were relief valves and 160 were control valves. By combining the valves, Conpar surely helped reduce the unit price, even though the two types of valves were of different types, and quite possibly manufactured at different locations. Although suppliers will quickly deny economies of scope, a case can be built for cost reductions based on their lower cost of sales, account management, and logistics (SG&A, broadly speaking).

Improving supply chain integration can reduce overhead or transport/logistics costs. Saudi Aramco's agreement with GE for a flow control center in Dammam includes stocking of component parts, which will save Saudi Aramco money through cost reduction as well as uptime improvements through guaranteed services levels.

Figure 30: Should-Cost for Relief Valves



9.3 Price Negotiation Strategies

1. When negotiating contracts with relief valve suppliers, aggregate volume over time and across facilities to capture the economies of scale that have been demonstrated and articulated here.
2. Combine relief valve purchases with purchases of other types of valves to achieve economies of scope. Nearly every major buyer that has contracted large agreements has aggregated multiple valve types in this way.
3. Initiate supplier supply chain reconfigurations to change their structural costs while margins are relatively low and they are eager for business. Costs are down and growth is relatively slow. A hard bargain from a large customer could incent suppliers to shift manufacturing or consolidate production, which would be a win-win.
4. Include Indian and Chinese companies on tender lists to enhance competitive leverage. Their prices are far enough below global levels to exert an equilibrating force on the prices of their Western competitors.

10 Control Valves

10.1 Market Overview

Table 17: Key Indicators for Control Valves
(Total Change over Each Period)

Key Indicators	Q1 2013 – Q1 2015		Q1 2013 – Q1 2020	
Demand Growth	▲	6.0%	▲	34.5%
Demand ($m)	▲	479-508	▲	479-645
Capacity Utilization	▲	3.0%	▲	3.1%
Prices	▲	3.3%	▲	13.7%

10.1.1 Demand

Control valves and systems have become more complex and specialized by industry and application in recent years. Customers are asking for total process engineering and optimization services and solutions.

Nearly 60% of Control valve sales are to the oil, gas, chemical, and power industries. Of these, about two-thirds are for the oil, gas, and chemical industries and about one third for the power industry. A minority are related to other process industries such as pulp and paper.

- Oil and gas applications include:
  - Natural gas processing
  - LNG
  - FPSO
  - Refining and petrochemicals
- Power industry applications include:
  - Coal
  - Combined cycle
  - CHP
  - Desalination
  - Nuclear Power
  - Feedwater regulation and purification systems

The scope of Control valves has both widened and become more specialized in recent years. For example, of 33 contracts noted later in this report, only 17 were for traditional control valves, while the rest were for either a specialized valve type, a system of valves, or a total package of system and services related to the valves. Here is a breakout of the recent contracts:

- 17 were for control valves in the simple sense, meaning that they were for:

  - Valves (of various types ranging from ball to butterfly)
  - Regulators and controls
  - Actuation systems
- 6 were for large-sized or specialized control valves such as:
  - Main Isolation Steam Valves (MSIPs)
  - Main Steam Isolation Valves (MSIVs) and main feedwater isolation valves (MFIVs)
  - Modulating steam control valves and auxiliary systems
  - Subsea production systems
- 5 were for control systems, including:
  - A core software application
  - Integration hardware
  - Control room instrumentation
- 5 were for consulting services and products related to optimization involving:
  - Flow control products, including valves
  - Engineering support services
  - Program oversight and project management
  - Management of third party vendors

The industry is migrating toward flow control solutions. Emerson Process is strongly influencing the migration by positioning its offering around intelligent multi-category intelligent technology based systems that tie valves together and add decision-making capability.

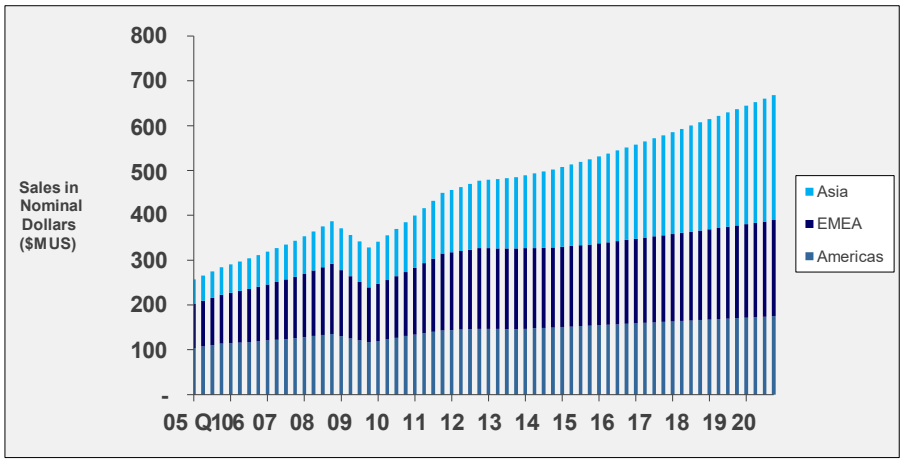
Demand for Control valves in the oil, gas, and chemical industries rose 4% in 2012 and will rise slightly less than 4% in 2013.

Currently, 55% of the demand comes from the NAFTA region and East Asia. From 2013 through 2017, the balance will shift by 2% away from NAFTA and toward East Asia.

Latin America is drawing more attention, especially Brazil. KOSO Kent Introl, which supplies control valves for a range of industries, recently signed a five-year agency agreement with RTS Valvulas, a Brazilian supplier, to better position itself for an impending wave of business from Petrobras and related oil and gas infrastructure companies operating in Brazil.

Demand will rise at 4% in 2013, 4.5% in 2014, and 5% annually from 2015 through 2020 as the industry takes a slight lead over inflation in a growing market, and expands the percentage of services in the total revenue mix.

Figure 31: Demand for Control Valves



10.1.2 Supply (Capacity)

Emerson added capacity worldwide. Circor expanded in India, and SPX and Severn clarified their focus on the energy markets, adding effective capacity to the market for control valves to the oil and gas industry.

The top control valve manufacturers for oil and gas applications are:

- Emerson
- GE
- Cameron
- Flowserve
- Circor
- Severn Glocon Group
- FMC technologies
- Valvitalia
- Samson Controls

There is roughly $650-$700m of total capacity per quarter, which is increasing. At an average 74-76% capacity utilization rate, there is adequate capacity, with room for megaprojects. Engineering labor rather than materials or shop capacity is the bottleneck factor input.

Emerson dominates the Control valve market, so its capacity additions drive the industry. Emerson has made several expansions in recent times:

- Emerson expanded facilities extensively over the past two years. In 2011 its board approved a $100m investment program that built administrative office space, technology centers, and manufacturing facilities around the world in places such as Houston and McKinney, Texas; Nanjing, China; and Sorocaba, Brazil. The expansion in Brazil alone was $35m, and it added 45k m^2.
- Emerson Process also expanded its facility in Székesfehérvár, Hungary, which is intended as a logistical platform for the company to better serve its European customers. The 6k m^2 facility, which opened last September, will make actuators and related control valve components. It should help shrink delivery times for European customers by up to 25%. The facility, which employs 550 people, is ISO 9001:2008 and PED (Pressure Equipment Directive) certified
- Emerson also expanded through acquisition. It bought Sanmar in India for its production and marketing of control valves, industrial regulators and other process technologies and services through the Fisher brand. It paid $135 million for Sanmar. It later renamed the unit Fisher Sanmar.

Circor built a new manufacturing facility at Ponnandampalayam near Coimbatore, India. The 60k ft2 unit currently houses 150 employees. Its intended uses include a 'Centre of Excellence' for manufacturing and engineering.

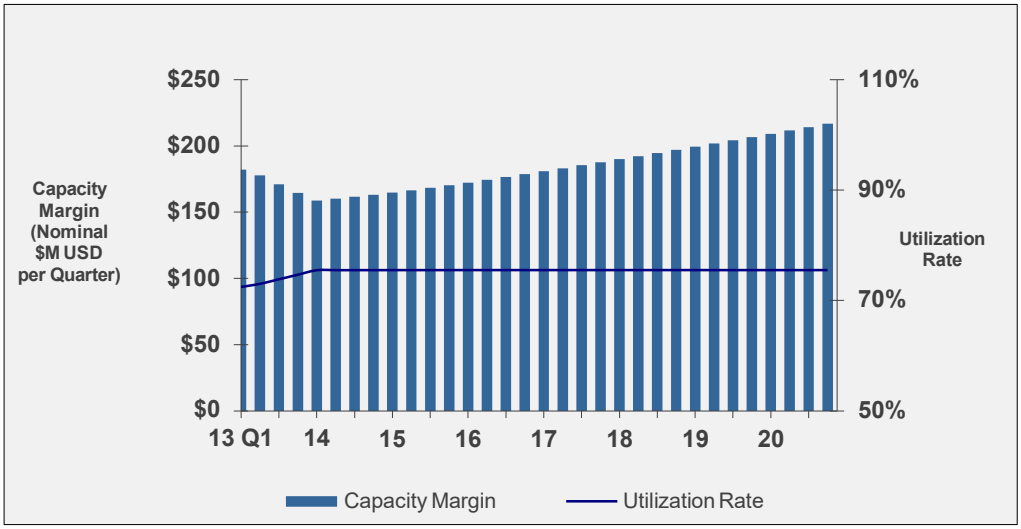
Although they are not capacity additions strictly speaking, several acquisitions and re-positionings changed the capacity landscape. For example:

- IMI purchased Remosa, an Italian valve manufacturer, to integrate into its control valve business. Remosa makes specialist valves such as fluid catalytic cracking slide valves, two port diverter valves, and expander butterfly valves. Remosa's access to IMI's global sales and aftermarket infrastructure is expected to improve Remosa's geographic penetration, notably in North America (it earns more than half of its revenue from South America).
- Circor's 2011 acquisition of the Brazilian valve supplier Válvulas S.F. Indústria e Comércio Ltda. adds a Latin American supplier of control and safety relief valves to buyers' potential bid lists. Válvulas, which focuses on making valves for the energy market, generated about $20m in 2010 revenue.
- SPX bought Copes-Vulcan, a subsidiary of DeZurik, for $30m, to add its control valves capability to its portfolio.
- Severn Unival, a North Sea supplier of Gate valves with a repair service center focused on Gate valves, decided to focus uniquely on control valves for the oil and gas industry.

At a capacity utilization rate of 74%, most suppliers can deliver comfortably on their new commitments.

Capacity utilization rates will increase only slightly (by less than a percent) as demand continues to grow. Emerson has invested sufficiently globally to provide capacity for growth, and smaller suppliers can augment their technical and engineering and supervisory staff as needed. In short, capacity margin appears not to pose a problem for most buyers.

Figure 32: Capacity Margin - Control Valves



Capacity utilization at the major suppliers indicates that capacity will not be scarce for large contracts:

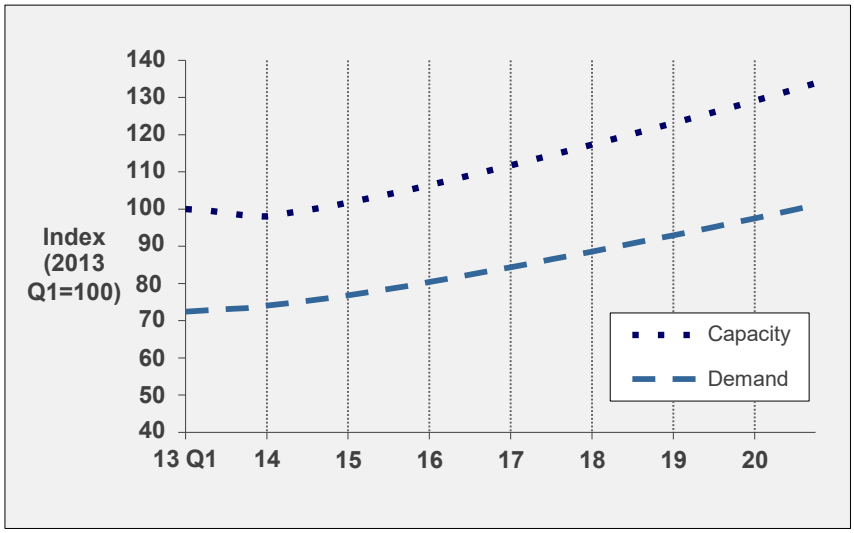
- Emerson is about 70% utilized, after adding substantial capacity worldwide.
- Flowserve is about 70% and projects that will increase to 79% within a year.
- Samson is 70% utilized and expects it to increase.
- Several other suppliers had figures in the same range.

Table 18: Reported or Estimated Capacity Utilization[1] Rates at Selected Control Valve Suppliers

Company	Country	Current Level	12-Month Forecast
Emerson	Worldwide	70%	70%
Flowserve	Worldwide	70%	80%
MTS	China	80%	80%
OCV Control Valves	USA	50%	55%
Samson	Worldwide	70%	75%
Samson	Worldwide	70%	75%
Tyco	Worldwide	75%	75%
Valvitalia	China	70%	70%
Valvitalia	Italy	70%	70%

For the time horizon of this study, we do not envisage major misalignments between capacity and demand.

Figure 33: Demand vs. Capacity - Control Valves



10.1.3 New contracts

BP, Chevron, and Saudi Aramco have been actively forming strategic supply agreement with control valve suppliers. Emerson, Severn Glocon, and Flowserve have been actively supplying major oil and gas projects.

[1] Capacity utilization means output as a percent of possible production where two shifts five days a week equals 100%. This methodology does not consider possible efficiencies from process improvements, which could free up capacity and reduce the effective capacity utilization rate.

The list of agreements for control valves and control valve solutions has been extensive. There is a sense among executives in the supplier community that suppliers are rushing to lock up the large buyers' multi-category requirements before competitors get them.

Due to the large number of contracts, we have separated them into two groups – agreements that resemble the 'reference product,' and other agreements that are more of the solutions variety being offered increasingly by Emerson and other leading suppliers in this industry.

Agreements that come close to the reference product specification include:

- BP selected Emerson as a preferred supplier for control valves for five oilfields in the North Sea in June 2012. BP is targeting the benefits of a single source relationship, including a single point of contact and more efficient and seamless project execution. It is also bundling training and maintenance support services into the agreement. The latter comes from a lifecycle asset management model, which starts at the FEED stage and involves installation and testing support. The agreement also involves predictive maintenance software.
- BP chose Severn Glocon to supply 450 control valves for its gas plant in Angola. The contract was for $6m, and the average price per valve was $13k. This project was priced to the customer's design specs, rather than being a percentage off list price.
- Chevron also chose Severn Glocon to supply control valves for its Gorgon project off of Australia. The applications include compressor anti-surge, blow down, gas to flare, low shear and flow control. Some of the valves are made of pure Inconel, which created manufacturing challenges.
- A utility grade combined heat and power (CHP) plant in Cheshire, UK, chose Emerson to automate its process control so as to minimize backwash from seawater, which was clogging a butterfly valve. Emerson introduced automation to make the butterfly valve into a control valve, which reduced the backwash.
- A Brazilian pump company, Eldorado Celulose e Papel S.A., chose Flowserve to supply control and on-off valves for its new plant, which is expected to be one of the world's largest single-line pulp plants.
- A UAE LNG plant chose Metso to supply its control valves in a $4m contract. The likely price per valve is $17-18k.
- A major international oil and gas company chose Mascot Australia to supply 16" 900# large, high pressure duplex globe control valves from its Melbourne plant, two of them for slug catcher applications. Duplex material was specified due to high corrosivity. Mascot also supplied high pressure drop angle style control valves for the project.
- Mascot also supplied low-temperature carbon steel control valves as part of a major international oil & gas company's expansion project at an existing facility. The valve body

castings were subcontracted. Mascot did the final assembly and non-destructive testing for all castings and valve components, including radiography and certified mill test reports.

- Nederlandse Aardolie Maatschappij (NAM) chose Emerson to automate a Dutch gasfield, including a contract to supply 1k Fisher control valves. The optimized automation system helps NAM control deliveries from 29 individual well clusters, each of which has about 10 wellheads, in a way that maximizes output from the field. NAM also uses the control system to provide preventive maintenance. It can use the data from the valves, through its software, to identify degradation in valve performance and take corrective action as needed.
- Saudi Aramco awarded Severn Glocon a control valve contract for the Wasit gas processing facility. Severn will manufacture the valves jointly in Gloucester, UK and in Saudi Arabia, (through a local partner named Binzagr) in order to conform to Saudi Arabia's local content preferences.
- Saudi Aramco chose Flowserve for a long-term agreement involving all flow products. The agreement calls for a facility in Saudi Arabia that will handle maintenance, repair, training, and parts management. Flowserve formed a joint venture with a local Saudi Arabian company to execute the program in the spirit of 'local content.'
- Shell established an Enterprise Framework Agreement with Flowserve for overall flow control solutions worldwide. Shell selected Flowserve based on its quality of the equipment, pricing, equipment standardization, and its ability to meet project delivery timelines.

Other agreements pertained to entire systems and/or larger equipment, but are instructive for learning about the same suppliers who supply oil and gas contracts.

- Petrofac awarded Severn Glocon a contract for 48 control valves for delivery in Malaysia to the Berantai project. The valves ranged between 1" and 14" in size, and from 300 to 2500 in pressure class. The valves were manufactured in the UK and India (Chennai) along with butterfly and Gate valves.
- The Donggi-Senoro LNG plant project in Central Sulaw esi, Indonesia awarded Severn Glocon a contract to supply control valves for cryogenic applications.
- The 225-MW combined-cycle Halmore power plant in Bhikki, Pakistan, awarded Emerson a contract to implement its Ovation process management system. The system will also interface to the unit's gas and steam turbines, air compression station and emergency diesel generator. In all, the Ovation system will manage more than 3k I/O points. Emerson will also provide onsite training for operators at the time of the installation. Emerson won a similar contract from the DTEK power plant in Ukraine.
- Emerson automated SECCO's 10-plant ethylene cracker complex in Shanghai which has thousands of control valves of different brands, types, and sizes. SECCO has reported improved control, production efficiency, and uptime, and a $40k savings in annual maintenance costs, through replacing valve positioners.

- Doosan, the EPC contractor for Saudi Electricity Company's (SEC) Rabigh Power Plant No.2 project, awarded Emerson a $10m contract for its Fisher® control valves for boiler, turbine gas, multi-stage flash desalination, and selective catalytic reduction applications as well as for the balance of plant. The contract is for 670 control valves at an approximate cost of $15k per valve, which is likely a 25% discount off the published price.
- Ekibastuz GRES-1 thermal power, the largest power plant in Kazakhstan, awarded Emerson two contracts to modernize its plant controls using Ovation technology. Under the first contract Emerson will modernize the controls for the steam turbine and turbine drives for feedwater pumps at six 500-MW units (Units 3-8). While the second contract is for digitally automating all major equipment and processes, including unit coordinator and startup and shutdown sequencing at Unit 8. Ekibastuz is also contemplating extending the scope of Emerson's Ovation control at Units 3-7.
- Petrobras made Emerson the main automation contractor for its Comperj project. Emerson will deliver engineering services, process automation, and systems integration for the refining unit, selected utilities, and offsite operations that are part of the project.
- A Brazilian Processing plant has awarded Dresser (GE) a contract worth approximately $5m for 250 valves to be used at the plant. The order comprises of 160 control valves and 90 relief valves at an average cost of $19k each.
- Southern Company awarded GE $10m contract for 50 utility grade control bypass valves worth about $20-25k each.
- KEPCO of South Korea signed a $38m agreement with Weir Valves & Controls for nuclear power plant valves. Weir will make 100 control valves to be supplied to Shin Ulchin, a South Korean nuclear plant, for safety related and severe service applications. The contract also covers valves for South Korea's first overseas nuclear contract, to be built at the Braka nuclear power plant in the U.A.E., which need to be delivered from 2013 through 2017.
- NTPC Limited (National Thermal Power Corporation), India's largest state-owned power generator, has contracted Velan to supply valves for the three 660 megawatt units of the Barh supercritical coal-fired power plant. The order includes high-pressure Gate, globe, and check valves and steam traps manufactured by Velan, as well as safety valves with silencers, control valves, butterfly valves, and actuators manufactured by six other companies in Europe. Velan will also supply six large 20" motor-operated forged Gate valves with Velan's patented Ultraflex™ high- pressure and high temperature wedge design.
- China Nuclear Energy Industry Corporation (CNEIC) has awarded Velan a contract for the supply of nuclear class control globe valves for the two new Russian-design pressurized water reactor type nuclear power plants of Tianwan Units 3 and 4, with delivery scheduled for 2014-15. Velan also received a separate contract from CNNC's Nuclear Power Company (known as CNNP) for spare parts for Qinshan II units 1-2-3-4. The contracts together are worth $9.75m spread over two years.
- The Ras Azawr Desalination Plant in Riyadh, Saudi Arabia, has ordered Circor/Pibiviesse to supply large control ball valves for a 450 km pipeline from the plant to Riyadh. Aside from a

variety of ball control valves of sizes ranging from 6" to 40", CIRCOR is also delivering two 64" X 48" hydraulic actuated control cage ball valves with flow capacity of 125,500 Cv, that are believed to be the largest ever of their kind in the world.

New contracts will come at an increasing rate, given the number of major capital projects underway and the increasing availability of specialized control valve designs that match the demands of higher pressure and higher temperature applications. Major projects are underway such as Maersk Oil's Chissonga FPSO, the Yanbu Aramco-Sinopec Refinery, and Statoil's Peregrino project located in the Campos basin offshore Brazil, just to name a few.

Table 19: Summary of New Contracts and Estimated Values for Control Valves

(Relatively Close Fit to the Reference Product)

Buyer	Country of Installation	Supplier	Product	Application	Estimated Value ($m)	Estimated Cost/Unit ($m)
BP	Angola	Severn Glocon	Control	LNG	$6	$13k
BP	UK (North Sea)	Emerson	Integrated Control and Safety Systems	Oil & Gas	N/A	$8.9
Chevron	Australia	Severn Glocon	Control Valves	Oil & Gas (Gas Processing)	N/A	N/A
Chevron (Gorgon)	Australia	Severn Glocon	Control	Gas Processing	N/A	N/A
E.ON Northwich	UK	Emerson	Butterfly Control Valve	Power (CHP)	N/A	$8.9
Eldorado Celulose e Papel, S.A	Brazil	Flowserve	Control Valves	Pulp & Paper	N/A	$7.9
LNG Plant	UAE	Emerson	Control Valves	LNG	N/A	$8.0
Major Oil Company	Southeast Asia	Mascot	Control	Oil & Gas (Slug Catcher)	N/A	N/A
NAM (Nederlandse Aardolie Maatschappij)	Netherlands	Emerson	Control Valves	Gas	1000 valves	$8,460
Saudi Aramco	Saudi Arabia	Flowserve	Control and Globe	Oil & Gas	N/A	$8.0
Saudi Aramco	Saudi Arabia	Severn Glocon	Control Valves	Oil & Gas (Gas Processing)	N/A	$8.0
Shell	Worldwide	Flowserve	Flow Control and Instrumentation	Oil & Gas	N/A	$7.6
Malaysia LNG	Malaysia	Flowserve	Control	N/A	$8	$6.9
DTEK	Ukraine	Emerson	Automation System	Power Plant (Coal)	N/A	N/A
E.ON	UK	Emerson	Butterfly Control Valve	CHP	N/A	$8.9
Haramidere Loading terminal	Turkey	Auma	Gate valve actuators	Unknown	N/A	N/A

Table 20: Summary of New Contracts and Estimated Values for Control Valves (Process Automation Systems and Services)

Buyer	Country of Installation	Supplier	Product	Application	Estimated Value ($m)	Estimated Cost/Unit ($m)
Goliat	Norway (Barents Sea)	Metso	Stainless Steel Valve Controllers	Oil & Gas (FPSO)	N/A	N/A
Huadian Lingwu Power Plant	China	Emerson	Control System (67 controllers, 20 work-stations and 70+ control valves)	Power (Coal)	$2.72	N/A
KEPCO	South Korea	Weir Valves	Control	Power (Thermal)	$37.50	$6.9
Petrobas	Brazil	Emerson	Engineering Services and Technologies	Oil & Gas	N/A	N/A
Petrobras	Brazil	Emerson	Automation General Contractor	Oil & Gas	N/A	N/A
Ras Azawr Desalination plant	Saudi Arabia	CIRCOR	Control Ball Valves	Desalination	N/A	N/A
Russian Boiler Manufacturer	India	Velan	Gate, Globe, Check, Control	Power (Thermal)	$9.80	N/A
SEC Rabigh Power Plant	Saudi Arabia	Emerson	Control Valves	Power Generation Feedwater	$10	$15k
Southern Company	US	Emerson	Control	Power	$10	$22.5k
BP	Worldwide	Cameron	Subsea Production Systems	Oil & Gas	N/A	N/A
CNPE	China	Flowserve	(MSIPs)	Nuclear Power	$10+	N/A
Ekibastuz GRES-1	Kazakhstan	Emerson	Control System Automation	Power (Coal)	N/A	N/A
Halmore Power Plant	Pakistan	Emerson	Control System	Power Plant (Coal)	N/A	N/A
KHNP	Korea	Flowserve	(MSIVs), (MFIVs)	Power (Nuclear)	N/A	N/A
Mississippi Power	US	GE	Modulating steam control valves	Power (Combined Cycle)	N/A	N/A
SECCO	China	Emerson	Automation General Contractor	Petrochemicals	N/A	N/A
Unnamed Client	China	Cameron	Subsea Systems	Oil & Gas	N/A	N/A

10.2 Analysis

10.2.1 Costs

Input costs for control valves are rising slowly and steadily due to modest labor cost inflation. Falling metals prices cushioned buyers from more than a 1% increase in 2012. On the presumption of continued low metals costs, overall Control valve price increases will remain below general industrial inflation.

Nearly 40% of the cost of Control valves relates to labor and benefits. Some control valves are highly engineered, especially large specialized and customized units. This results in disproportionally higher engineering and professional labor costs than for other valve types.

Still, 29% of the cost relates to metals, the price of which generally decreased in 2012 (depending on the type and grade).

15% of the cost is for electronics, including thermosetting resins and plastics materials, printed circuit board, semiconductors, electronic capacitors, electronic resistors, and electronic wire and cable. Despite intra-year volatility, plastics prices have not driven inflation in the price of control valves. For example, LDPE, which rose and fell by 14% several times during the past 12 months, is back where it was a year ago.

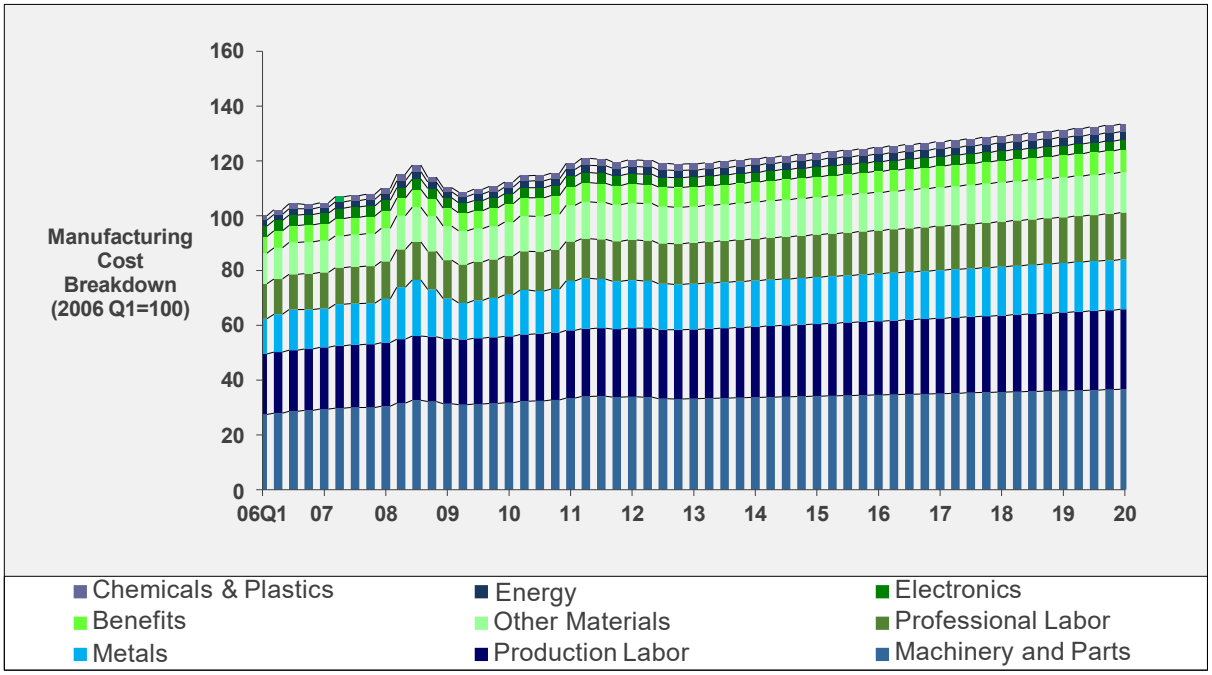
Labor costs are growing at only 0.5% per quarter, or slightly over 2% per year, on average. Less expensive East European and Asian factory labor is replacing expensive American and European labor as factories continue to shift eastward where much of the demand is.

Overall, prices rose slightly less than 1% in 2012. However, as the outlook appears stable and promising for Control valves and the effects of the recession fade, we predict price inflation of 1.3% to 1.6% per year from 2013-2015, for a cumulative 6.0% inflation in the prices of control valves.

Suppliers will largely pass the rising cost of professional and engineering labor through to buyers in the pricing of large process automation projects, as suppliers have discretion as to how to price large projects.

The rate of price growth will increase from 2015 through 2020, rising from 1.6% per year to 2.0% per year, based on continued wage inflation and stabilizing metals costs

Figure 34: Cost Structure of Control Valves



Note: Prices are ex-works.

10.2.2 Profit Margins

Suppliers make profit on large process automation projects, and use value-based pricing. Instead of profit per valve, suppliers measure in increments of large installations such as refineries or power plants.

Control valve manufacturers earn more profit on control valves than on other valve types. Leading control valve manufacturers earned 13.4% operating margin and 6.5% net margin. This is significantly higher than the average of all valve manufacturers, who have a collective operating margin of 10.6% and an average net margin of 5.7%.

- Emerson, the world leader in control valves, made an operating profit margin of 15.8% in its Process Management division.
- GE, which is traditionally one of the most profitable suppliers, earned an operating margin of 23.5% and a net margin of 9.6% in its Oil & Gas segment.

- FMC Technologies, another control valve manufacturer, earned an operating profit of 11.0% and a net margin of 7.8%.

Suppliers earn this higher profit because control valves are different in important ways from the simpler valve types, such as ball, butterfly, Globe and Gate. Control valves are highly customized/engineered, so suppliers are offering design engineering services and commissioning services that enhance margins and provide significant benefit to buyers , lessening the customers' need to acquire and employ this type of expertise as part of their fixed cost structure.

All vendors attempt to 'upsell' control valves as instrumentation packages and solutions. Emerson and Flowserve are expert at managing large automation projects, and can deliver strong benefits in these areas. In cases where project becomes process management or project management for large-scale process control optimization, then the cost and price of the individual valves is small compared to the revenue from the project.

Suppliers increase their profit by building intelligence into high-end valves and the software that reports valve conditions to central monitoring stations. Most have the ability to integrate to PMS (Plant Mgt Systems) through common communications protocols such as Backnet .

10.2.3 Prices

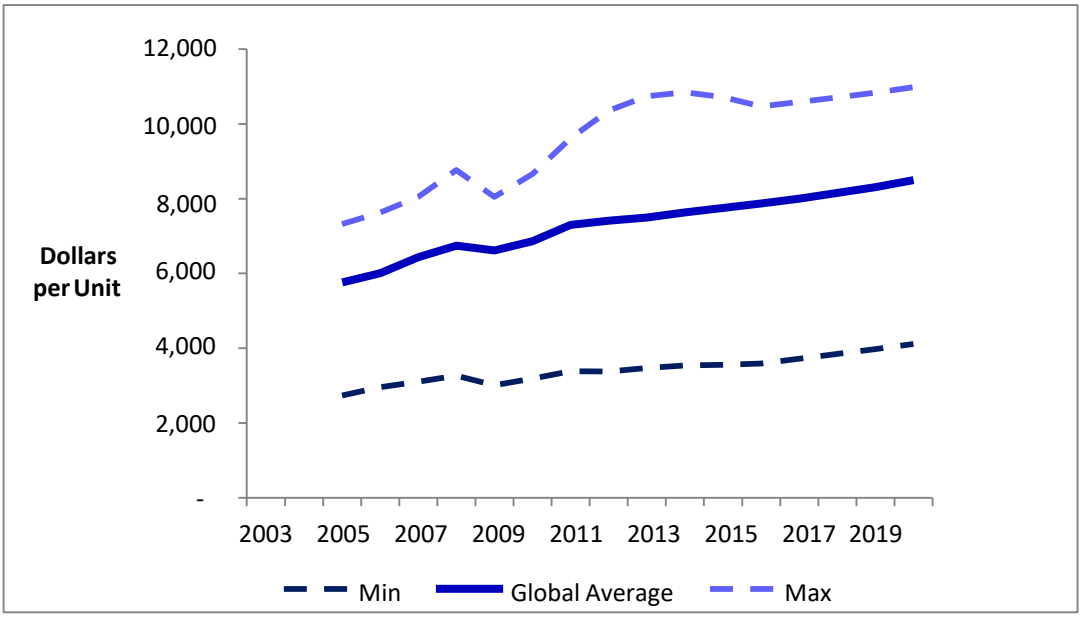
Prices of Control Valves are escalating at 2-3% per year, and are increasingly influenced by a services-oriented sales bundling by the major suppliers, particularly Emerson.

Prices have risen by 2-3% per year for the last two years. With Emerson as the dominant supplier (according to our estimates, it controls approximately a quarter of the world market for control valves of the specification of the reference product, for oil and gas applications), the supplier base is stable.

Prices are set to increase by 3.3% by 2015 and 13.7% by 2020, following a stable path of cost increase, volume growth, and incremental, progressive, and profitable expansion.

In this environment, suppliers know their costs exceedingly well, so buyers may be better off negotiating on the basis of total value provided by the valves rather than by cost per unit.

Figure 35: Overall Price Forecast for Control Valves



US, European,, and Russian prices for control valves are approximately on par with one another. Japanese prices are higher, and Latin American prices are lower.

Japanese prices are over 20% higher than their North America price benchmarks. In contrast, Latin American and African prices are calculated at about 10% lower. African valves are typically industrial rather than petroleum grade, and are commonly imported. Local production is actually decreasing in some countries such as South Africa, as the supplier industry struggles to remain competitive with global manufacturers.

As with other types of valves, India and China are the lowest cost sourcing locations due to their plentiful labor and low cost of steel.

Table 21: Regional Price Variations over Time for Control Valves

Region/Country	Today	2014	2015	2020
North America	1.00	1.01	0.99	1.05
Latin America	0.91	0.96	0.98	1.21
Europe	1.02	1.03	1.03	1.10
Africa	0.92	0.94	0.93	1.03
India	0.40	0.41	0.41	0.48
Russia	0.97	1.00	1.03	1.23
China	0.55	0.56	0.55	0.59
Japan	1.23	1.25	1.24	1.27
Other Asia	0.79	0.80	0.80	0.83

10.2.4 Price Differences by Technology, Model, and Feature

Control valves differ in price according to their size, material, and pressure class. Based on a carbon steel unit of 300 pressure class, the following relationships are evident:

- A one-inch increase in the diameter leads to a $725 increase in price.
- Upgrading from carbon steel to stainless steel (316) increases the price by 1.25 times.
- Upgrading from carbon steel to stainless steel (317L) increases the price by 1.52 times.
- Increasing the pressure class from 300 to 600 increases the price by $7.76 per incremental digit of pressure class rating.

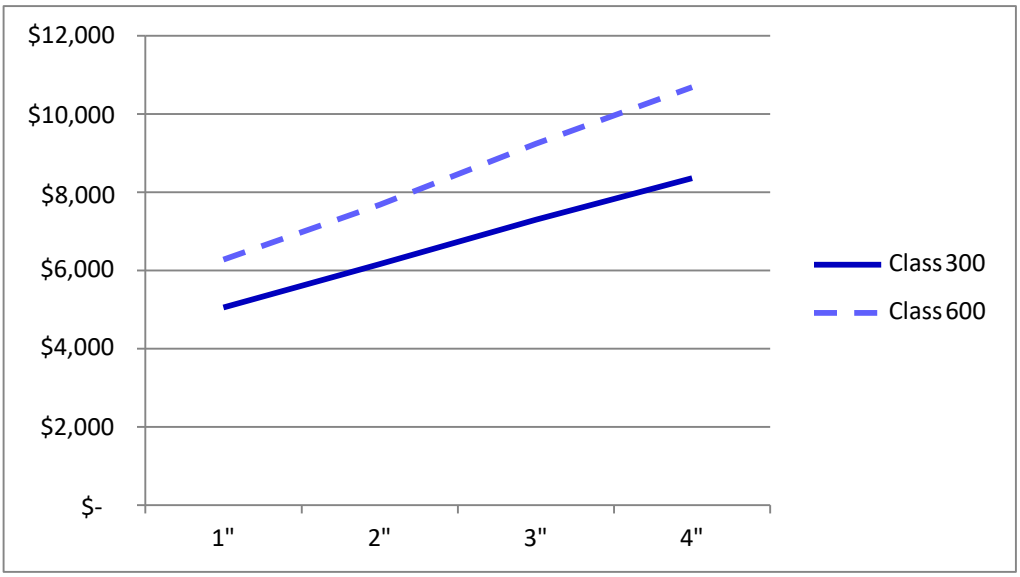
Table 22: Incremental Cost per Extra Parameter or Feature (Indicative) for Control Valves

Parameter or Feature	Unit of Measure	Indicative Cost Impact	Notes / Comments
Size	Diameter (inches)	$725/inch (based on carbon steel)	Cost grows proportional to size
Material	Carbon steel as reference point	1.25x for stainless steel 316	1.52x for Stainless 317L
Pressure Class	150, 300, 600, 900, 1500	+ $7.76 per incremental pressure class rating	Cost grows proportional to pressure class

Note: Changing one parameter usually involves changing others, and the cost impact may not be additive or linear.

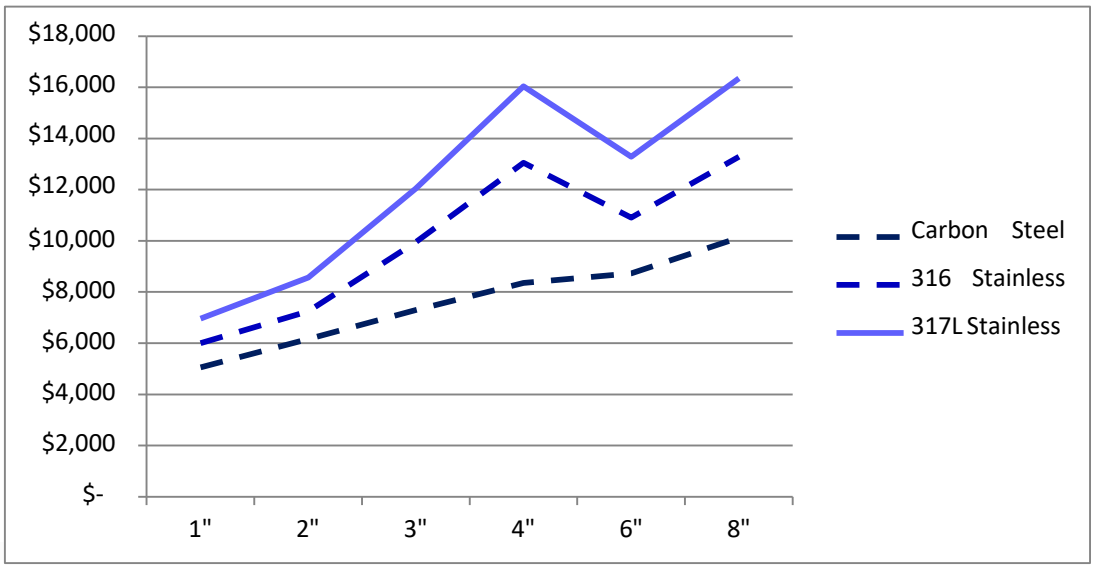
The cost of control valves is proportional to diameter from one to four inches, which is the relevant range for the reference product. Price increases slightly faster on Control valves made to pressure class 600 than on Control valves manufactured to pressure class 300 (the slope is slightly steeper).

Figure 36: Control Valve Size vs. Cost - by Pressure Class



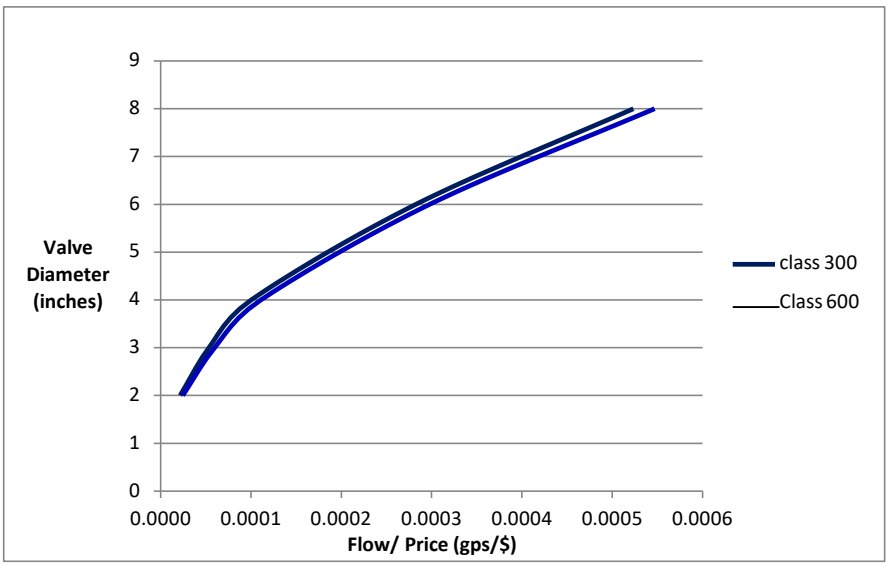
Smaller control valves (1”-4”) will typically use globe type valves, whereas larger control valves (6” and larger) will typically use ball type valves. Globe valves provide better flow control in smaller sizes while ball valves are more economical to fabricate in the larger sizes. Hence, the price for 6” and larger valves yields a price break (see chart below). The price break also applies to the carbon steel valves, but with carbon steel the price difference isn’t enough to lower the price between 4” and 6” valves.

Figure 37: Control Valve Size vs. Cost - by Material (Class 300)



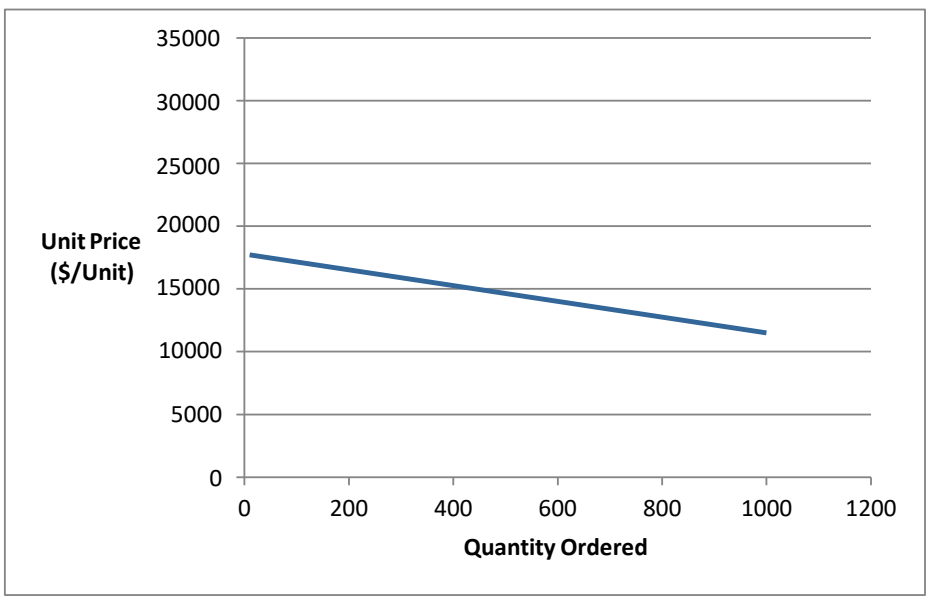
The additional cost per inch of diameter pays off in increased output, but to diminishing degrees as the diameter increases. The incremental increase in flow per dollar expended increases from 2' to 3" diameter. However, after about 3.5" in diameter, the rate of payback decreases in a linear fashion.

Figure 38: Output Flow for Each Extra Dollar Spent vs. Control Valves Size - by Pressure Class



Economies of scale factor importantly into the price of control valves. Based on an analysis of seven contracts, and making a variety of assumptions, ordering 100 units will achieve a price discount of about 3%.

Figure 39: Economies of Scale in Control Valves



10.2.5 Should-Cost Analysis

Based on the aforementioned analysis of costs and prices, buyers should target 15% savings on control valves.

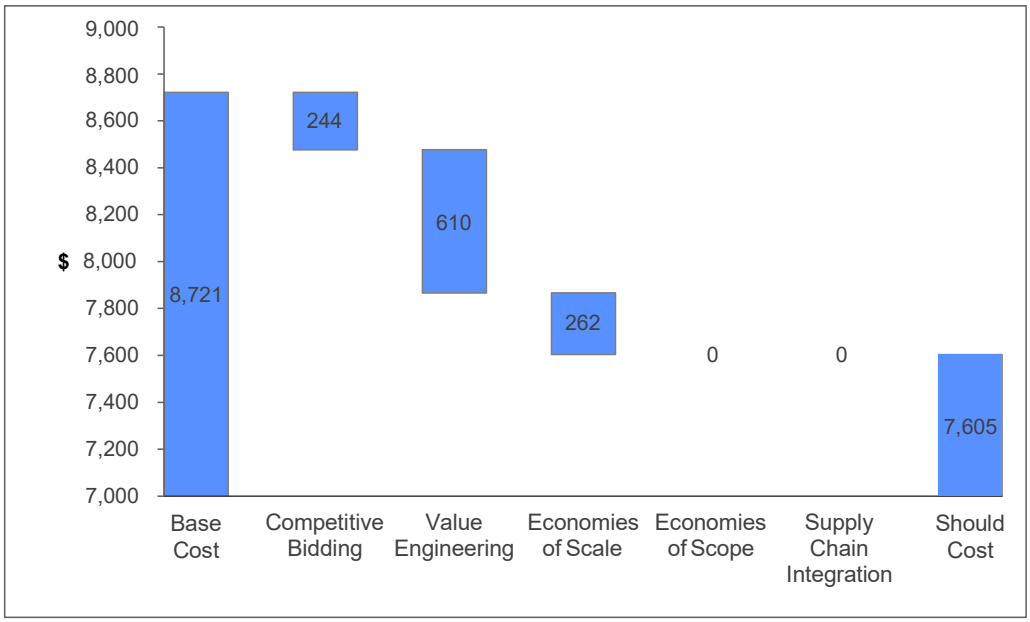
They can achieve the most gains by dealing with control valve suppliers as solutions providers rather than commodity product vendors, and jointly seeking throughput improvements through better process control. Companies like PTT Thailand have achieved a 7% benefit factor from throughput improvement enabled by process optimization. PTT Group used simulation software to raise output at its Gas Separation Plant No. 5 in Rayong, Thailand. The firm implemented software from Aspen Technology, increasing production and plant capacity to 107% of design capacity @ 530 MMSCFD (100%). The increase in output raised the plant's profitability by $46,000 per day and increased production by 126,000 tons per year.

They can also reduce the unit purchase price by buying in bulk. As discussed, economies of scale are 3% for 100 units, and could increase from there. Nederlandse Aardolie Maatschappij (NAM) ordered over 1k control valves from Emerson to automate a Dutch gasfield. In this case, the average price is estimated at well below the reference product's $8,721 per-unit cost.

As discussed, the average operating profit margins of control valve manufacturers are 2.8% higher than for other valve types, which is a target for strategic sourcing savings. As a benchmark, GE's operating profit, at 23.5%, is over twice the industry average.

Supply chain integration is always a potential source of savings insofar as it can reduce overhead and transport/logistics costs. Knowing this, Severn Glocon built a warehouse in Dubai to serve the Middle East region, hoping to reduce its SG&A costs for customers in that region.

Figure 40: Should-Cost for Control Valves



10.3 Price Negotiation Strategies

1. Leverage suppliers' growing engineering expertise to optimize process flow and control. Engage them to help reduce total cost by optimizing process automation across the plant.
2. Order in volume to help suppliers achieve economies of scale in manufacturing.
3. For sourcing purposes, consider classifying control valves under Instrumentation instead of Valves since the suppliers' business model fits more with that category.
4. Scan the market for customized and specialized valves that suit each particular application. The proliferation of new valves coming onto the market is opening up new possibilities for higher temperature, higher pressure operation than before.

4. Reference product definitions and scope

1. Gate

- Carbon steel with SS 316 trim
- 6" diameter
- Pressure class: 150
- Max working temp: 800° F
- API 600 or 602

2. Globe

- Carbon steel with SS 316 trim
- 6" diameter
- Pressure class: 150
- Max working temp: 800° F
- API 600 or 602

3. Relief

- Carbon steel
- 6-8" diameter
- Pressure class: 300
- Max working temp: 800° F
- API 520 and 521

4. Control

- Carbon steel with SS 316 trim
- 6" diameter
- Pressure class: 300
- Max working temp: 800° F
- Air-actuated

4. Notes

The suppliers who were contacted directly for this study include, but are not limited to:

- Brodie
- Crane
- Emerson
- Flowserve
- FMC
- Kimray
- MSA
- MTS
- OCV
- OMNI
- Pentair (Tyco)
- PTPA
- Raymond
- Ritag
- Samson Controls
- Sodeco
- Valvitalia
- Valvosider
- Velan

10.6 Data

Category: Gate Valves

Key Indicators for Gate Valves

Key Indicators	2013 Q1-2015 Q1		2020 Q1	
Demand	▲	5.5%	▲	35.1%
Order Lead Time	▲	3.5%	▲	3.8%
Prices	▲	3.2%	▲	13.6%
Capacity Utilization	▲	2.0%	▲	2.0%
Supplier Concentration	LO	0.2%	LO	7.2%

Demand for gate valves in Q1 is projected to be 6.7% higher than in Q1.
Lead Times for gate valves in Q1 are projected to be 0.5% lower than in Q1.
Prices for gate valves in Q1 are projected to be 7.9% higher than in Q1
Capacity Utilization for gate valves in Q1 is projected to be 0.2% lower than in Q1

Demand for Gate Valves

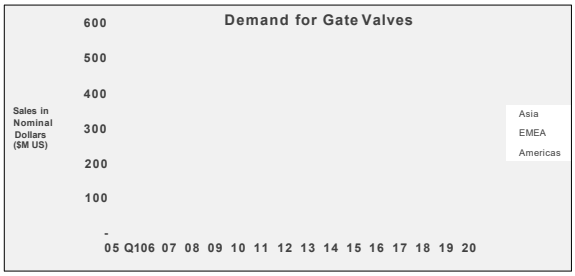
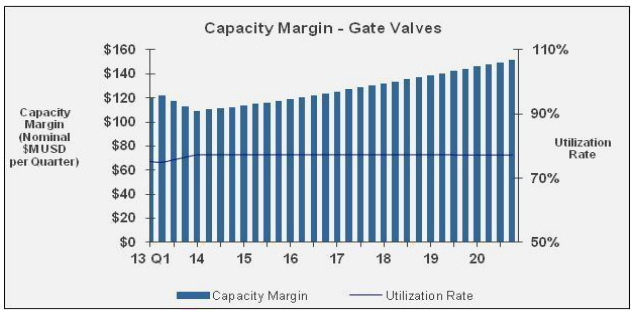


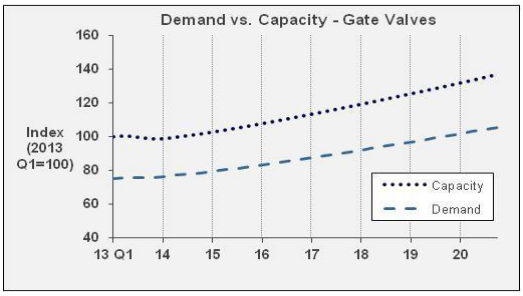
Chart Name	2005	2006	2007	2008	2009
Americas	92.12	96.70	100.98	106.80	94.56
EMEA	85.77	96.38	110.07	126.65	104.68
Asia	52.88	59.86	66.94	74.62	74.80

Capacity Margin - Gate Valves



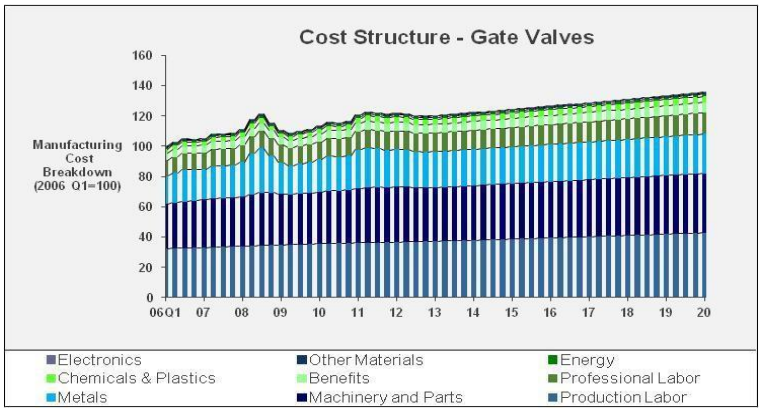
		2013Q1	2013Q2	2013Q3	2013Q4
Capacity Margin - Millions of Dollars		$120	$122	$118	$113
Utilization Rate		75.3%	75.0%	75.7%	76.5%

Demand vs. Capacity - Gate Valves



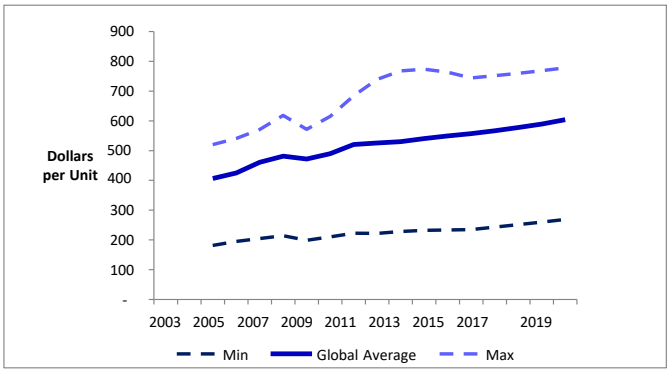
		2013Q4	2014Q4	2015Q4	2016Q4
Estimated Sales (Millions of US Dollars)		$368	$382	$400	$420
Capacity (Millions of US Dollars)		$481	$494	$517	$544

Cost Structure - Gate Valves



		2006Q1	2006Q2	2006Q3	2006Q4
Production Labor		32.40	32.56	32.68	32.91
Machinery and Parts		29.50	30.06	30.80	31.10
Metals		18.30	19.71	20.92	20.39
Professional Labor		10.50	10.59	10.70	10.78
Benefits		4.90	4.93	4.97	5.00
Chemicals & Plastics		2.40	2.66	2.64	2.41
Energy		1.00	1.03	1.06	0.98
Other Materials		0.70	0.71	0.73	0.73
Electronics		0.30	0.30	0.30	0.30

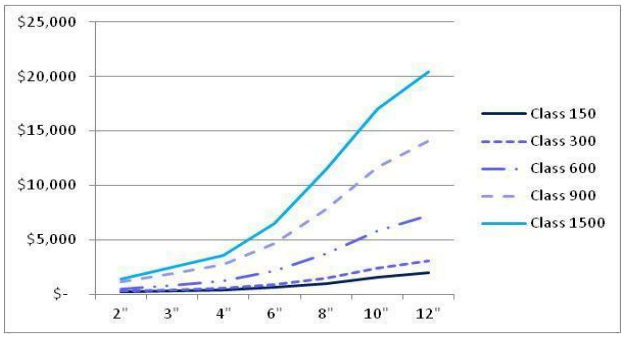
Overall Price Forecast for Gate Valves



ACTUAL PRICES IN US DOLLARS

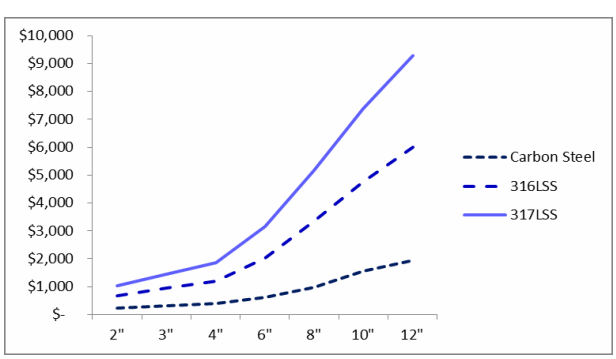
Year	Min	GlobalAverage	Max
2005	183	406	524
2006	196	425	544
2007	205	461	572
2008	213	482	616
2009	201	472	572
2010	211	490	613
2011	222	521	682
2012	222	526	739
2013	228	530	768
2014	232	540	774
2015	232	550	763
2016	233	557	743
2017	241	567	750
2018	250	578	757
2019	258	589	766
2020	267	604	775

Gate Valve size vs. Cost – by Pressure Class



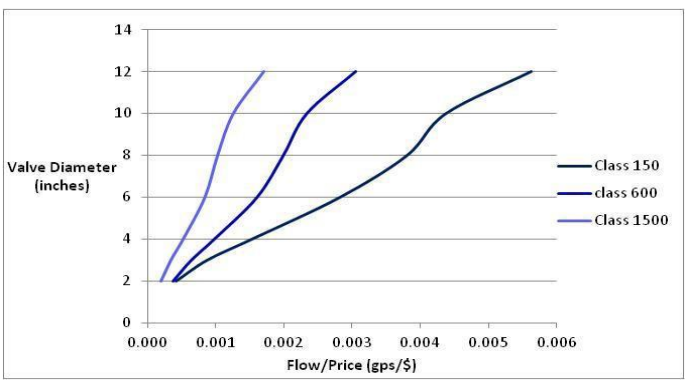
Size	Class150	Class300	Class600	Class900	Class1500
2"	$ 225	$ 303	$ 504	$ 1,132	$ 1,443
3"	$ 316	$ 438	$ 861	$ 1,943	$ 2,498
4"	$ 388	$ 550	$ 1,213	$ 2,748	$ 3,557
6"	$ 617	$ 897	$ 2,169	$ 4,682	$ 6,527
8"	$ 983	$ 1,455	$ 3,757	$ 7,834	$ 11,511
10"	$ 1,547	$ 2,370	$ 5,797	$ 11,673	$ 17,035
12"	$ 1,955	$ 3,079	$ 7,206	$ 14,100	$ 20,462

Gate Valve size vs. Cost – by Material



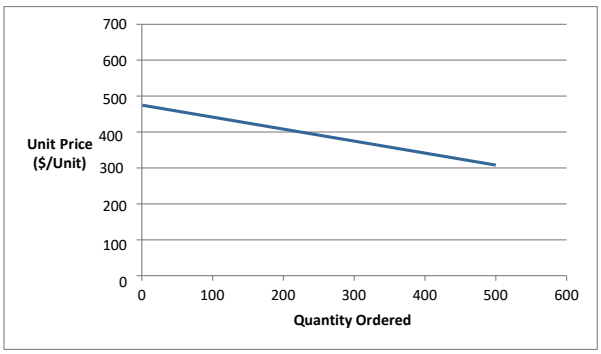
					GATE VALVES
ASTM A216 Gr. WCB (Carbon Steel)					
Size	Class150	Class300	Class600	Class900	Class1500
2"	$ 225	$ 303	$ 504	$ 1,132	$ 1,443
3"	$ 316	$ 438	$ 861	$ 1,943	$ 2,498
4"	$ 388	$ 550	$ 1,213	$ 2,748	$ 3,557
6"	$ 617	$ 897	$ 2,169	$ 4,682	$ 6,527
8"	$ 983	$ 1,455	$ 3,757	$ 7,834	$ 11,511
10"	$ 1,547	$ 2,370	$ 5,797	$ 11,673	$ 17,035
12"	$ 1,955	$ 3,079	$ 7,206	$ 14,100	$ 20,462

Output flow for each extra Dollar spent vs. Gate Valve size – by Pressure Class



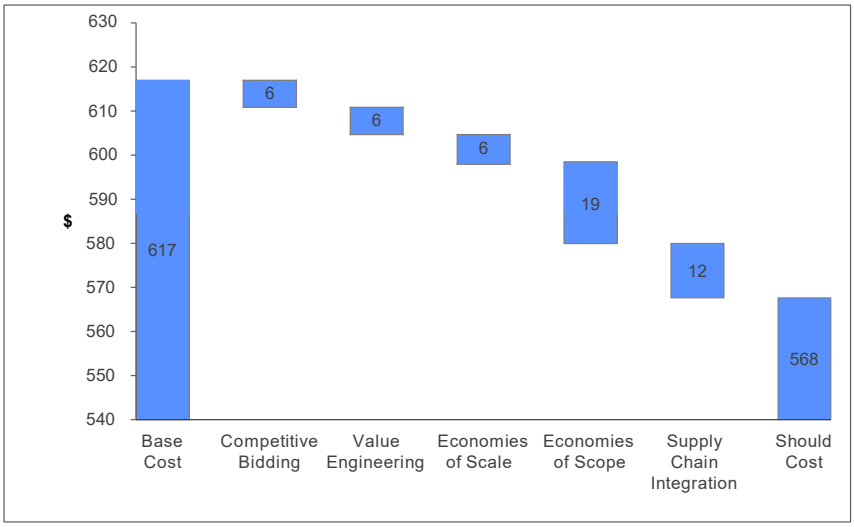
D (in)	Q/Price (g/s/$)		
	Class150	Class600	Class1500
2	0.00042	0.00037	0.00021
3	0.00087	0.00064	0.00035
4	0.00153	0.00098	0.00053
6	0.00282	0.00161	0.00084
8	0.00381	0.00199	0.00103
10	0.00438	0.00234	0.00126
12	0.00563	0.00306	0.00170

Economies of Scale - Gate Valves



Slope Equation:	y=-0.4167x+515.65	
	Units	Unit Price ($/unit)
Start Point:	1	$ 515.23
End Point:	500	$ 307.30

Should-Cost for Gate Valves



Category: Globe Valves

Key Indicators for Globe Valves

Key Indicators	2013 Q1-2015 Q1		2020 Q1	
Demand	▲	5.5%	▲	32.6%
Order Lead Time	▲	6.1%	▲	6.1%
Prices	▲	3.0%	▲	12.9%
Capacity Utilization	▲	2.2%	▲	2.2%
Supplier Concentration	LO	0.3%	LO	7.2%

Demand for globe valves in Q1 is projected to be 5.5% higher than in Q1.
Lead Times for globe valves in Q1 are projected to be 6.1% higher than in Q1.
Prices for globe valves in Q1 are projected to be 3.0% higher than in Q1
Capacity Utilization for globe valves in Q1 is projected to be 2.2% higher than in Q1

Demand for Globe Valves

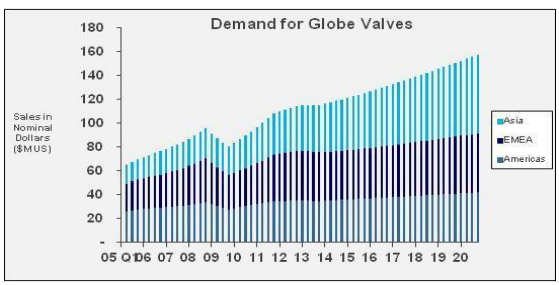
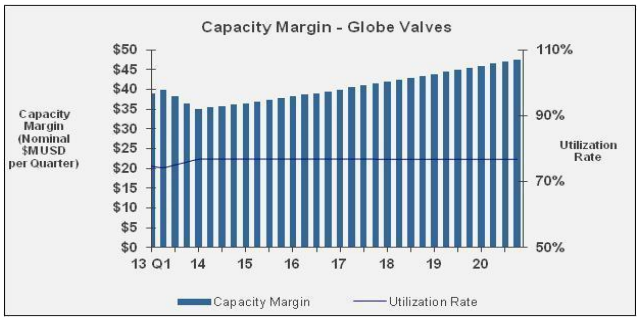


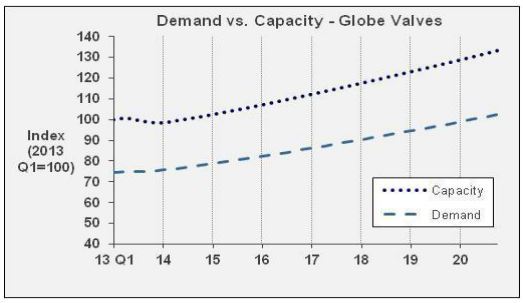
Chart Name	2005	2006	2007	2008	2009
Americas	27.71	29.00	30.76	33.64	27.68
EMEA	25.08	27.82	31.37	36.82	28.76
Asia	17.01	19.81	21.87	25.24	23.77

Capacity Margin - Globe Valves



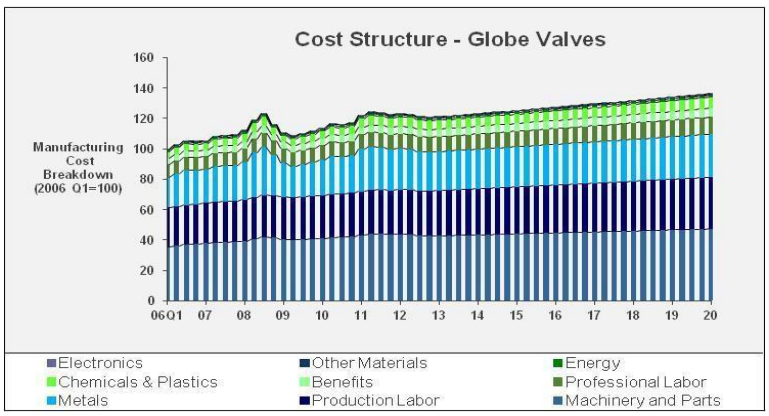
		2013Q1	2013Q2	2013Q3	2013Q4
Capacity Margin - Millions of Dollars		$39	$40	$38	$36
Utilization Rate		74.6%	74.2%	75.1%	75.9%

Demand vs. Capacity - Globe Valves



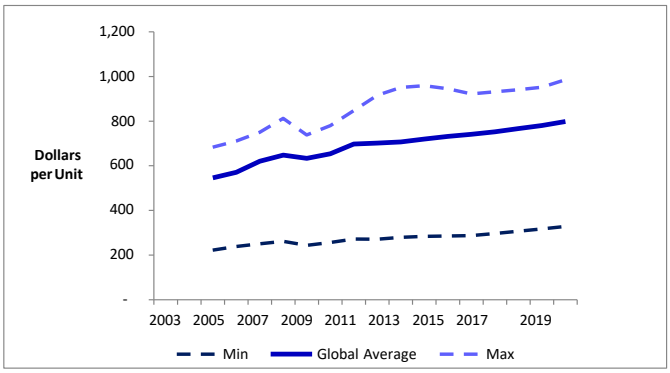
		2013Q4	2014Q4	2015Q4	2016Q4
Estimated Sales (Millions of US Dollars)		$115	$120	$125	$131
Capacity (Millions of US Dollars)		$152	$156	$163	$171

Cost Structure - Globe Valves



		2006Q1	2006Q2	2006Q3	2006Q4
Machinery and Parts		35.40	36.07	36.95	37.32
Production Labor		25.90	26.03	26.12	26.30
Metals		20.00	21.54	22.86	22.28
Professional Labor		8.40	8.47	8.56	8.62
Benefits		4.20	4.23	4.26	4.29
Chemicals & Plastics		4.10	4.55	4.51	4.11
Energy		1.00	1.03	1.06	0.98
Other Materials		0.70	0.71	0.73	0.73
Electronics		0.30	0.30	0.30	0.30

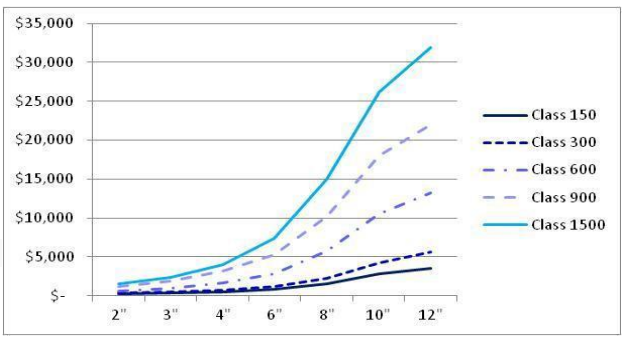
Overall Price Forecast for Globe Valves



ACTUAL PRICES IN US DOLLARS

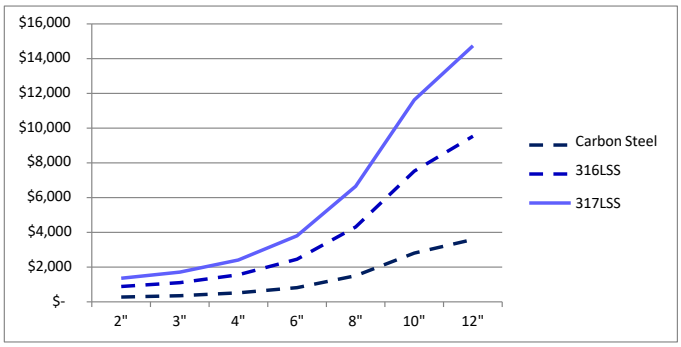
Year	Min	GlobalAverage	Max
2005	222	546	684
2006	239	571	711
2007	250	621	750
2008	262	648	813
2009	243	634	738
2010	257	654	780
2011	272	697	848
2012	271	702	916
2013	279	707	951
2014	284	719	959
2015	285	732	946
2016	287	741	922
2017	297	752	931
2018	307	767	941
2019	318	781	952
2020	328	799	985

Globe Valve size vs. Cost – by Pressure Class



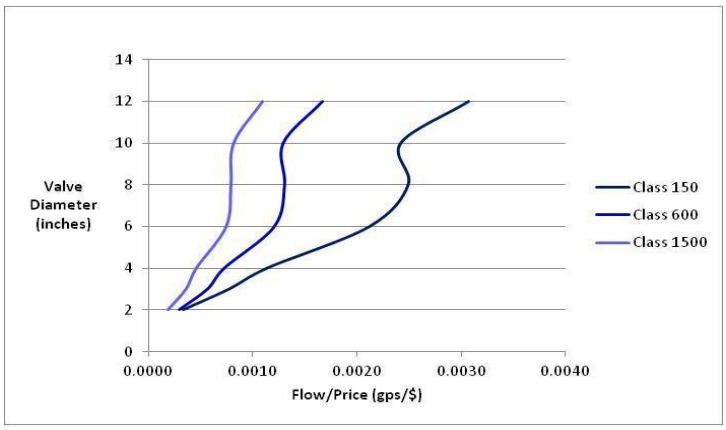
Size	Class150	Class300	Class600	Class900	Class1500
2"	$ 281	$ 378	$ 630	$ 1,202	$ 1,531
3"	$ 356	$ 493	$ 969	$ 1,860	$ 2,391
4"	$ 521	$ 737	$ 1,627	$ 3,134	$ 4,056
6"	$ 822	$ 1,194	$ 2,888	$ 5,299	$ 7,386
8"	$ 1,505	$ 2,226	$ 5,750	$ 10,190	$ 14,973
10"	$ 2,805	$ 4,296	$ 10,509	$ 17,986	$ 26,248
12"	$ 3,589	$ 5,653	$ 13,228	$ 22,002	$ 31,929

Globe Valve size vs. Cost – by Material



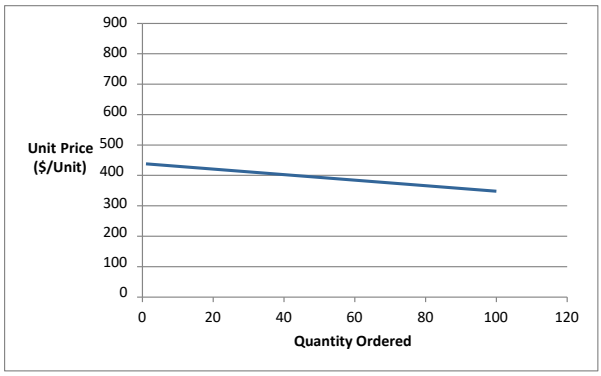
GLOBEVALVES						
ASTM A216 Gr. WCB (Carbon Steel)						
Size	Class150	Class300	Class600	Class900	Class1500	
2"	$ 281	$ 378	$ 630	$ 1,202	$ 1,531	
3"	$ 356	$ 493	$ 969	$ 1,860	$ 2,391	
4"	$ 521	$ 737	$ 1,627	$ 3,134	$ 4,056	
6"	$ 822	$ 1,194	$ 2,888	$ 5,299	$ 7,386	
8"	$ 1,505	$ 2,226	$ 5,750	$ 10,190	$ 14,973	
10"	$ 2,805	$ 4,296	$ 10,509	$ 17,986	$ 26,248	
12"	$ 3,589	$ 5,653	$ 13,228	$ 22,002	$ 31,929	

Output flow for each extra Dollar spent vs. Globe Valve size – by Pressure Class



D (in)	Q/Price (g/s/$)		
	Class150	Class600	Class1500
2	0.0003	0.0003	0.0002
3	0.0008	0.0006	0.0004
4	0.0011	0.0007	0.0005
6	0.0021	0.0012	0.0007
8	0.0025	0.0013	0.0008
10	0.0024	0.0013	0.0008
12	0.0031	0.0017	0.0011

Economies of Scale - Gate Valves



Slope Equation:	y=-1.0292x+448.69	
	Units	Unit Price ($/unit)
Start Point:	1	$ 447.66
End Point:	100	$ 345.77

Should-Costs for Globe Valves

Category: Relief Valves

Key Indicators for Relief Valves

Key Indicators	2013 Q1-2015 Q1		2020 Q1	
Demand	▲	5.5%	▲	35.4%
Order Lead Time	▲	0.2%	▲	0.2%
Prices	▲	3.0%	▲	12.8%
Capacity Utilization	▲	0.9%	▲	0.9%
Supplier Concentration	LO	0.2%	LO	7.2%

Demand for relief valves in Q1 is projected to be 5.5% higher than in Q1.
Lead Times for relief valves in Q1 are projected to be 0.2% higher than in Q1.
Prices for relief valves in Q1 are projected to be 3.0% higher than in Q1
Capacity Utilization for relief valves in Q1 is projected to be 0.9% higher than in Q1

Demand for Relief Valves

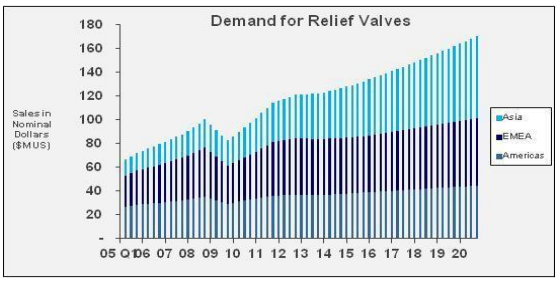
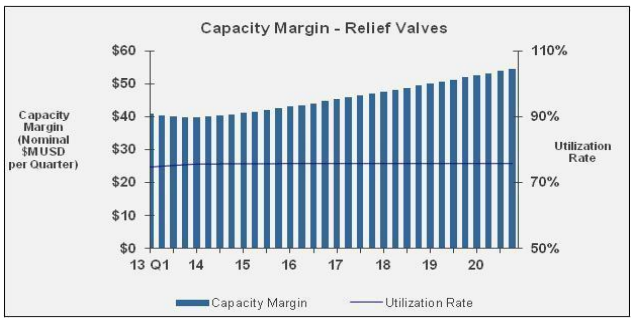


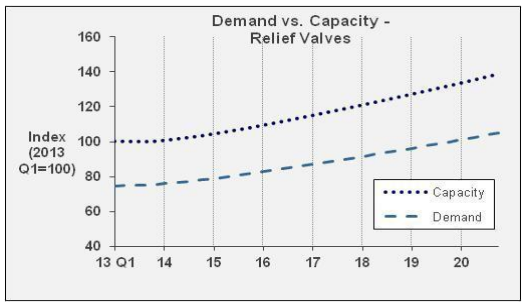
Chart Name	2005	2006	2007	2008	2009
Americas	28.28	30.01	31.91	35.06	29.18
EMEA	28.80	32.10	35.93	41.75	32.04
Asia	14.85	17.33	19.66	23.44	21.29

Capacity Margin - Relief Valves



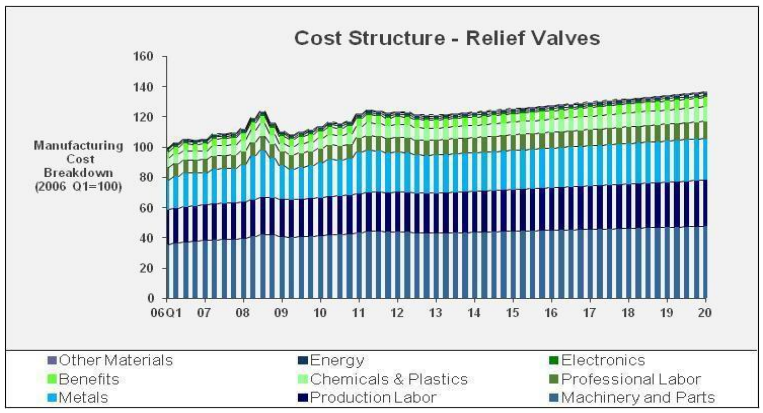
		2013Q1	2013Q2	2013Q3	2013Q4
Capacity Margin - Millions of Dollars		$41	$40	$40	$40
Utilization Rate		74.8%	75.0%	75.2%	75.4%

Demand vs. Capacity - Relief Valves



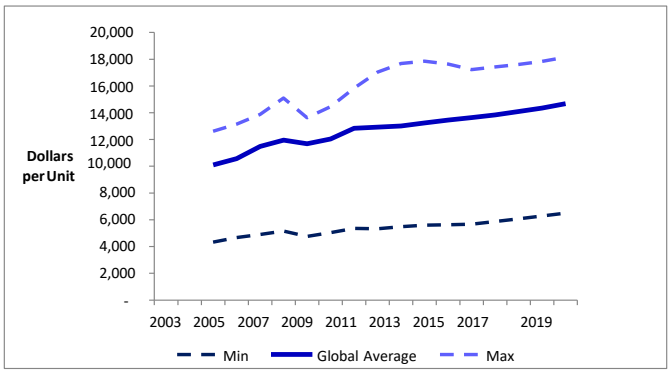
		2013Q4	2014Q4	2015Q4	2016Q4
Estimated Sales (Millions of US Dollars)		$122	$126	$132	$139
Capacity (Millions of US Dollars)		$162	$167	$175	$184

Cost Structure - Relief Valves



		2006Q1	2006Q2	2006Q3	2006Q4
Machinery and Parts		35.65	36.32	37.22	37.59
Production Labor		23.20	23.32	23.40	23.56
Metals		19.50	21.00	22.29	21.72
Professional Labor		8.45	8.53	8.61	8.67
Chemicals & Plastics		5.60	6.22	6.16	5.62
Benefits		4.55	4.58	4.62	4.64
Electronics		1.40	1.40	1.40	1.40
Energy		1.00	1.03	1.06	0.98
Other Materials		0.65	0.66	0.68	0.68

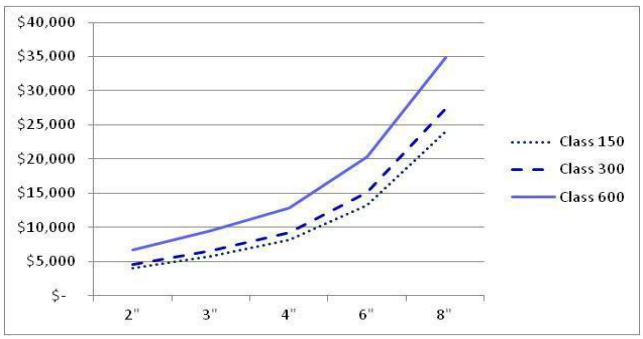
Overall Price Forecast for Relief Valves



ACTUAL PRICES IN US DOLLARS

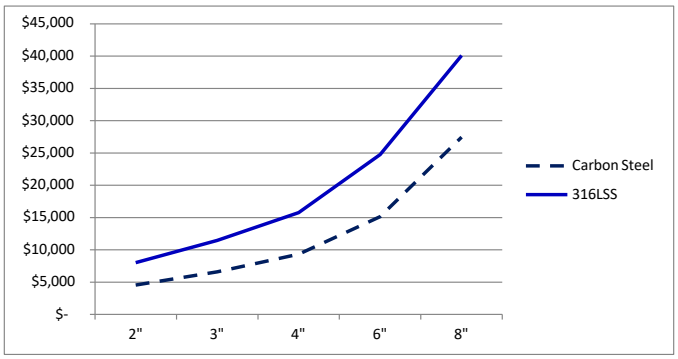
Year	Min	GlobalAverage	Max
2005	4,328	10,096	12,611
2006	4,680	10,574	13,143
2007	4,901	11,486	13,873
2008	5,156	11,956	15,105
2009	4,757	11,685	13,635
2010	5,041	12,037	14,461
2011	5,352	12,837	15,834
2012	5,336	12,925	17,037
2013	5,492	13,010	17,680
2014	5,594	13,236	17,847
2015	5,627	13,458	17,632
2016	5,674	13,636	17,228
2017	5,875	13,836	17,426
2018	6,077	14,091	17,615
2019	6,285	14,346	17,836
2020	6,499	14,671	18,148

Relief Valve size vs. Cost – by Pressure Class

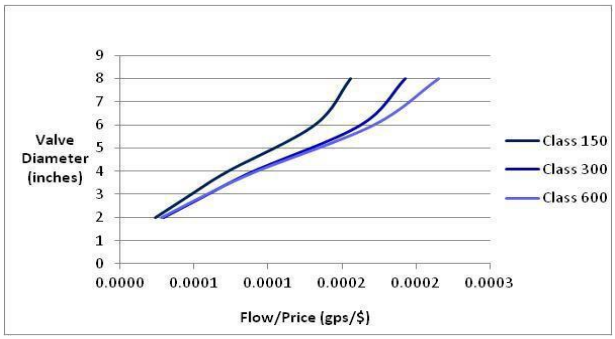


Size	Class150	Class300	Class600
2"	$ 3,982	$ 4,540	$ 6,747
3"	$ 5,783	$ 6,593	$ 9,467
4"	$ 8,164	$ 9,308	$ 12,885
6"	$ 13,272	$ 15,132	$ 20,356
8"	$ 24,079	$ 27,455	$ 34,852

Relief Valve size vs. Cost – by Material



RELIEF VALVES					
ASTM A216 Gr. WCB (Carbon Steel)				ASTM A351 Gr. CF8M (316 Stainless Steel)	
Size	Class150	Class300	Class600	Class150	Class300
2"	$ 3,982	$ 4,540	$ 6,747	$ 7,034	$ 8,020
3"	$ 5,783	$ 6,593	$ 9,467	$ 10,049	$ 11,457
4"	$ 8,164	$ 9,308	$ 12,885	$ 13,833	$ 15,772
6"	$ 13,272	$ 15,132	$ 20,356	$ 21,705	$ 24,748
8"	$ 24,079	$ 27,455	$ 34,852	$ 35,171	$ 40,101



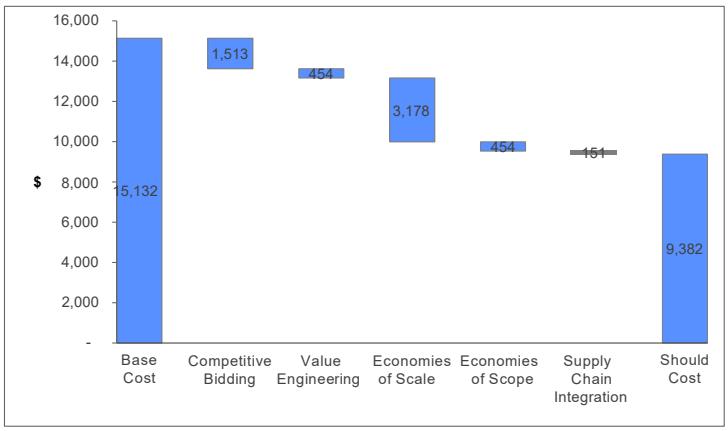
D (in)	Q/Price(g/s/$)		
	Class150	Class300	Class600
2	0.0000	0.0000	0.0000
3	0.0000	0.0001	0.0001
4	0.0001	0.0001	0.0001
6	0.0001	0.0002	0.0002
8	0.0002	0.0002	0.0002

Economies of Scale - Relief Valves



Slope Equation:	y=-73.633x+15206	
	Units	Unit Price ($/unit)
Start Point:	1	$ 15,132.37
End Point:	50	$ 11,524.35

Should-Costs for Relief Valves



Category: Control Valves

Key Indicators for Control Valves

Key Indicators	2013 Q1-2015 Q1		2020 Q1	
Demand	▲	6.0%	▲	34.5%
Order Lead Time	▲	5.2%	▲	5.6%
Prices	▲	3.3%	▲	13.7%
Capacity Utilization	▲	3.0%	▲	3.1%
Supplier Concentration	LO	0.2%	LO	7.2%

Demand for control valves in Q1 is projected to be 6.0% higher than in Q1.
Lead Times for control valves in Q1 are projected to be 5.2% higher than in Q1.
Prices for control valves in Q1 are projected to be 3.3% higher than in Q1
Capacity Utilization for control valves in Q1 is projected to be 3.0% higher than in Q1

Demand for Control Valves

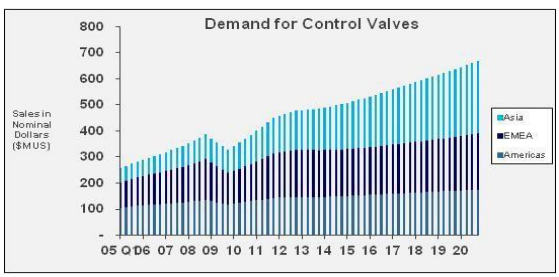
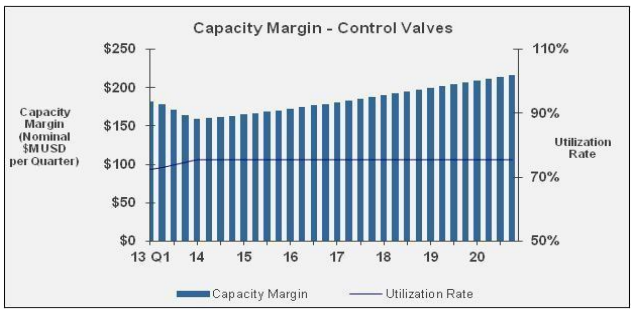


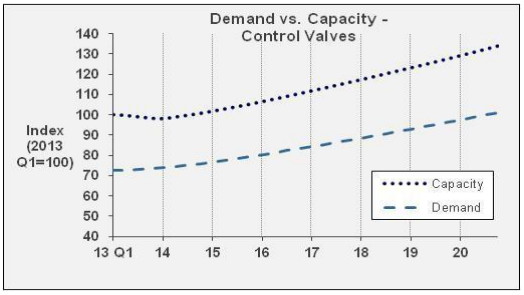
Chart Name	2005	2006	2007	2008	2009
Americas	113.53	118.91	125.80	135.54	116.34
EMEA	109.56	121.58	136.71	156.18	122.68
Asia	60.87	70.56	80.63	94.78	89.08

Capacity Margin - Control Valves



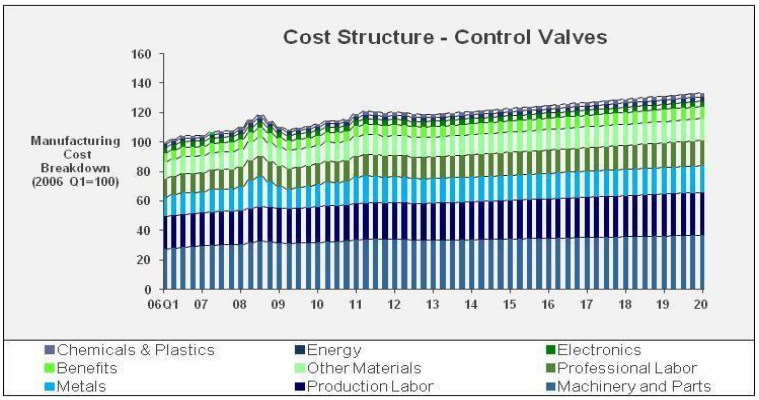
		2013Q1	2013Q2	2013Q3	2013Q4
Capacity Margin - Millions of Dollars		$182	$178	$171	$165
Utilization Rate		72.5%	73.0%	73.8%	74.7%

Demand vs. Capacity - Control Valves



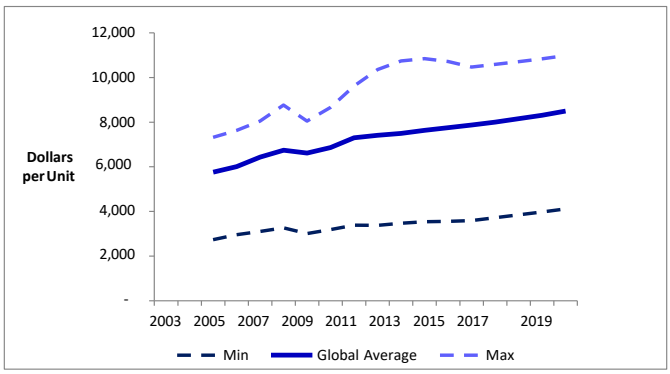
		2013Q4	2014Q4	2015Q4	2016Q4
Estimated Sales (Millions of US Dollars)		$485	$503	$525	$551
Capacity (Millions of US Dollars)		$650	$666	$695	$730

Cost Structure - Control Valves



		2006Q1	2006Q2	2006Q3	2006Q4
Machinery and Parts		27.47	27.98	28.67	28.96
Production Labor		22.10	22.21	22.29	22.44
Metals		12.90	13.89	14.75	14.37
Professional Labor		12.70	12.81	12.95	13.04
Other Materials		11.17	11.40	11.62	11.63
Benefits		6.10	6.14	6.19	6.23
Electronics		3.83	3.83	3.83	3.83
Energy		2.13	2.20	2.26	2.09
Chemicals & Plastics		1.60	1.78	1.76	1.60

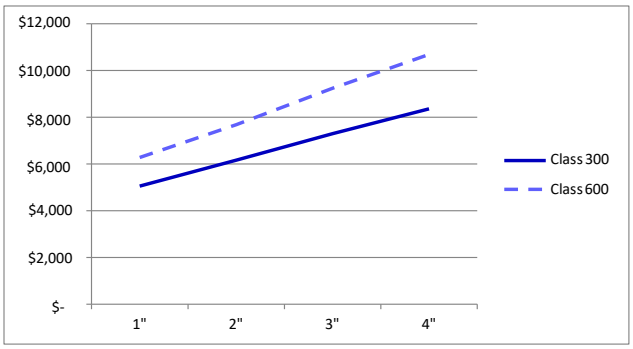
Overall Price Forecast for Control Valves



ACTUAL PRICES IN US DOLLARS

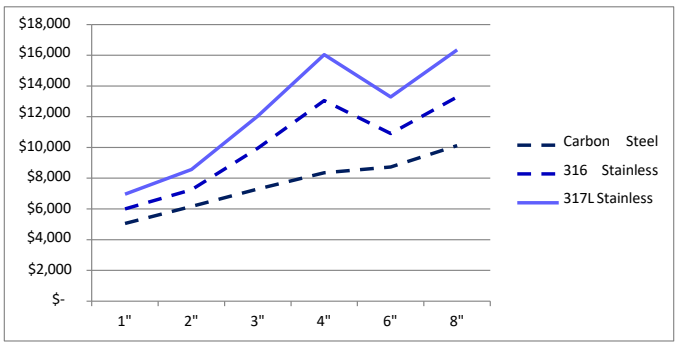
Year	Min	GlobalAverage	Max
2005	2,830	5,758	7,471
2006	3,005	6,012	7,799
2007	3,117	6,433	8,142
2008	3,222	6,747	8,673
2009	3,103	6,617	8,492
2010	3,219	6,863	8,955
2011	3,364	7,300	9,707
2012	3,377	7,416	10,341
2013	3,474	7,498	10,747
2014	3,548	7,632	10,880
2015	3,587	7,758	10,823
2016	3,635	7,871	10,631
2017	3,762	8,003	10,721
2018	3,894	8,152	10,814
2019	4,030	8,306	10,933
2020	4,170	8,501	11,057

Control Valve size vs. Cost – by Pressure Class



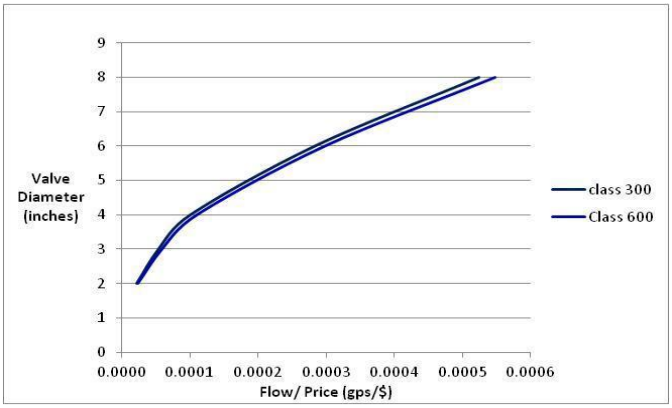
Size	Class300	Class600
1"	$ 5,048	$ 6,273
2"	$ 6,161	$ 7,679
3"	$ 7,291	$ 9,237
4"	$ 8,356	$ 10,683
6"	$ 8,721	
8"	$ 10,122	

Control Valve size vs. Cost – by Material



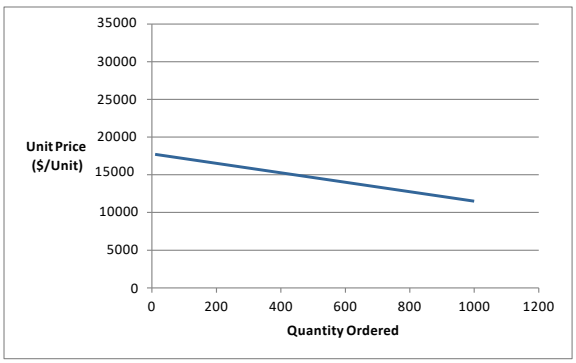
CONTROL VALVES						
	ASTM A216 Gr. WCB (Carbon Steel)		ASTM A351 Gr. CF8M (316 Stainless Steel)		ASTM A351 Gr. CG3M (3
Size	Class 300	Class 600	Class 300	Class 600	Class 300
1"	$ 5,048	$ 6,273	$ 5,996	$ 7,408	$ 6,957
2"	$ 6,161	$ 7,679	$ 7,241	$ 8,972	$ 8,561
3"	$ 7,291	$ 9,237	$ 9,946	$ 12,342	$ 12,044
4"	$ 8,356	$ 10,683	$ 13,046	$ 16,122	$ 16,036
6"	$ 8,721	[redacted]	$ 10,911	[redacted]	$ 13,287
8"	$ 10,122	[redacted]	$ 13,288	[redacted]	$ 16,347

Output flow for each extra Dollar spent vs. Control Valve size – by Pressure Class



D (in)	Q/Price (g/s/$)	
	Class 300	Class 600
2	0.00002	0.0000
3	0.00005	0.0001
4	0.00010	0.0001
6	0.00028	0.0003
8	0.00052	0.0005

Economies of Scale - Control Valves



Slope Equation:	y=-6.281x+17770	
	Units	Unit Price ($/unit)
Start Point:	1	$ 17,763.72
End Point:	1000	$ 11,489.00

Should-Costs for Control Valves

