

The Problem with Pipe Flanges

Pipe leaks in a plant or the field can prove extremely hazardous to workers and the environment. A place to look for leaks is where pipe sections connect. In situ flange facing puts a Band-Aid on the problem, but does not address the root cause. If the flange angle is incorrect, it can push mating pieces out of alignment and add dangerous tension. Solution: Dimensional Flange Management. It's the process of measuring digitally for faster, more accurate flange repair – and greater safety.

Pipe leaks are a nightmare. Whether at an oil refinery, a power plant, or a chemical processing facility, the material leaked from faulty piping can be poisonous...and potentially deadly.

Worker safety and a healthy environment are the top concerns. But the financial impact can't be ignored. When a plant must shut down sections of piping to repair leaks, production stalls, and the costs can be tremendous. Losses can run to the hundreds of thousands of dollars – even millions – when a plant's high-volume operations get interrupted.

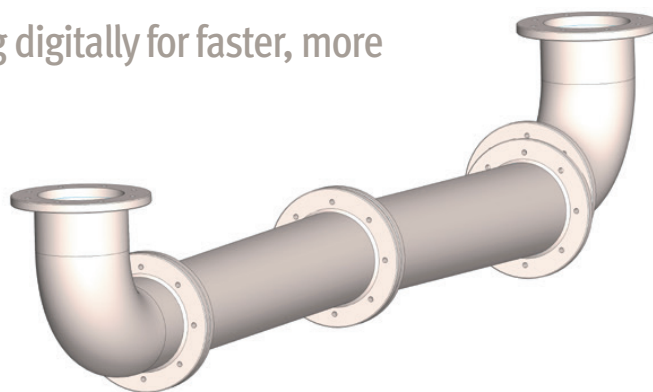
In most plants, the standard solution is to take manual measurements of the problematic flange and use field-machining equipment to re-face it. Then, to ensure a match, the same is done for the mating surface of the flange on the connecting section of pipe. Still, the plant solves their problem only temporarily, without addressing the root cause.

Of big concern – but too often overlooked – is the precise angle of the flange. Through re-facing, it can change, even by just a degree, and it may force a change in the angle of the mating flange on the connecting pipe section. This introduces new tension in the connection, especially where the gaskets seal the ring of bolts to the flange's surface.

The danger compounds around elbow joints, where pipes turn at 90-degree angles. There may be three or more pipe sections to redirect the material flow. So a change in one flange angle may be felt, not only in the mating flange, but also in the connecting flanges at the other ends of the pipe sections on either side of it – and even further upstream and downstream in the full piping system. The stored tension can multiply throughout.

Reducing Need for Re-facing

Now add the pressures of heat and vibration. Even when the angle of piping has warped only slightly due to re-facing, the natural forces of the material's flow can increase significantly. Gaskets must squeeze and stretch to maintain the integrity of the seal. What's more, the usual high wear and tear at the curves in elbow joints can intensify.



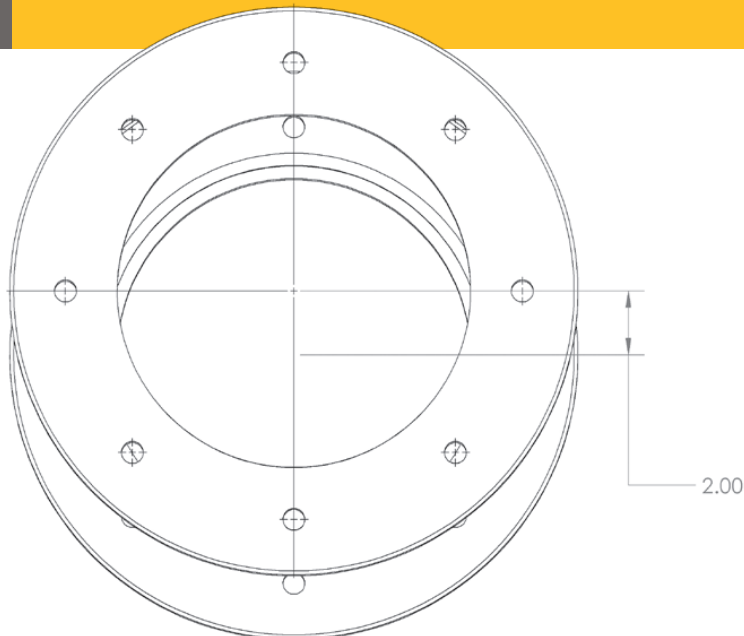
Risks for leaks compound at elbow joints, where pipes turn at 90-degree angles. The challenge is to keep mating flanges parallel and pipe flow perpendicular. A change in one flange angle may be felt, not only in the mating flange, but also in the flanges at the other ends of the connected pipe section. Stored tension can multiply throughout the system.



If each pipe section is, say, 36 inches around, the flange may have as many as 36 sealed bolts. This creates many risks for leaks. There may be high tension on gaskets at some “clock” positions, and low tension at opposite ends. The effort to maintain the proper parallel positions of these flanges and gaskets – and the piping’s perpendicularity in elbow-joint configurations – may require regular re-facing work.

This is where the innovative pipe measurement and machining work of Dimensional Engineering, Inc. is making a change for the better. Customers rely on the Michigan-based company to help meet their toughest design and production engineering challenges.

Improving the process of repairing and preventing leaks in industrial piping systems is a Dimensional Engineering specialty. Over the years they have inspected pipe flanges



at oil refineries and other energy facilities in Texas and nearby states. To better serve their customers in the area, the company opened a Houston office earlier this year.

Dimensional Engineering has found that companies are acutely aware of their pipe flange re-facing issues, and are eager to find better ways to address them. “Pipe leaks are a constant topic in the daily safety meetings at many plants,” said William Bonner, the company’s managing director. “At one unit in a refinery, we found that over 50% of the pipe flanges had needed to be resurfaced within the previous year. That simply can’t go on.”

In a Fraction of the Time

Dimensional Engineering applies 3D metrology technology to aid in geometric dimensioning and tolerancing (GD&T). Their process is often referred to, with only partial accuracy, as “reverse engineering.” The company’s field

engineers use the latest laser tracking and scanning equipment – with scanners often mounted to a portable coordinate measuring machine (CMM) – to collect pipe measurements.

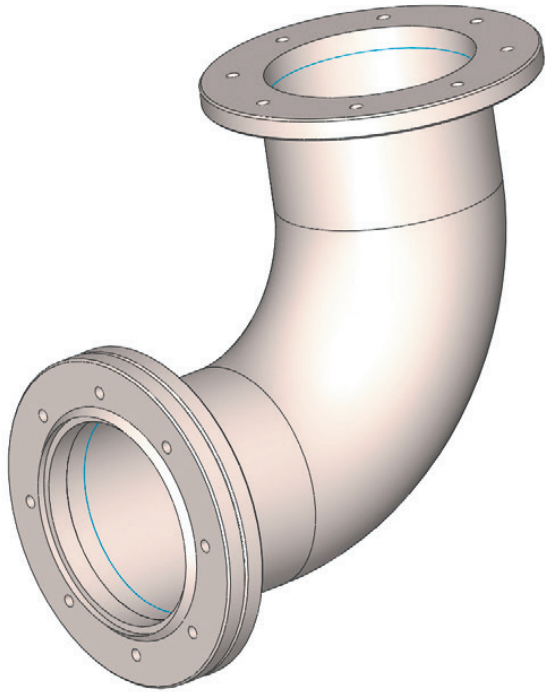
“Measuring digitally increases accuracy,” said Bonner. “It also saves time. All pipe data needed can be captured in a fraction of the time required by hand measurements.”

Dimensional Engineering uses the term “Dimensional Flange Management” to describe their innovative approach to the problem with pipe flanges. Jason Self has been the company’s chief project engineer on pipe leak repair projects. He noted, “We capture literally millions of data points on a pipe’s connections. We can document, with high accuracy, the entire envelope of the most complex pipe joint configuration. This makes the repair project completely traceable and repeatable.”

A pipe section’s ring flange may have many bolts – and many risks for leaks. A flange just slightly out of proper angle adds and reduces tension on gaskets at opposite “clock” positions. Aligning the flanges can require frequent re-facing. Worse, the problem may repeat down the line in connecting pipe sections. Maintenance costs can mushroom.

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CMM readings are imported into computer-aided design (CAD) software to show the impact of alternative flange re-facing scenarios. Finite element analysis points to high-stress and low-stress areas in the pipe connections. The Dimensional Engineering team tests and tweaks the flange re-facing plane in the coordinate system until determining how to stop the leak with the least amount of bending and pulling on mating flanges and gaskets.

Flanges are re-faced onsite with high-accuracy field machining equipment. Mating flanges remain parallel – and are perpendicular with the next set of connections in an elbow joint. Tolerances are within 0.002 of an inch – much tighter than normally achievable with machining based on hand measurements and only a surface indicator. Tension stays at levels the piping was designed for. There's little or no need to use come-alongs to align pipes.

“Measuring digitally increases accuracy and saves time. All data can be captured in a fraction of the time required with hand measurements.”

Face-to-Face Flange Control

“There are only so many times you can re-face a pipe flange,” said Self. “Eventually you’ll need to rebuild the pipe connection. But if you re-face the flange more accurately, it may go for years without adding stress. This cuts way down on maintenance. Plant managers can feel like they’re not constantly chasing their tails on pipe flange leaks.”

The digital way provides face-to-face dimensional control on flange ends and helps reduce the time and expense of pipe maintenance. More urgently, it helps protect workers from hazardous risk. There's hardly a cost saving that could be more crucial.



SOLUTION AT A GLANCE

Using 3D Metrology Technology to Keep Pipe Flanges Aligned

Save time. By replacing hand measurements with laser tracking and scanning, surface dimensions needed for inspecting and assessing flange alignment can be collected in hours instead of days. Validating designs digitally further speeds the task.

Cut costs. The field engineering team can find and correct equipment problems digitally before making physical modifications. The solution works right the first time. This can save millions of dollars by preventing interruptions in plant production.

Enhance precision. Capturing a complex system's dimensions in digital mode helps document the entire flange alignment project in a highly accurate, up-to-date, as-built 3D point cloud. The project is fully traceable and more easily repeatable.

Dimensional Engineering's preferred tools for capturing digital measurements of industrial



equipment include laser trackers, scanning arms, and laser scanners. The company analyzes the collected data using PolyWorks®, the universal 3D metrology software platform™ from InnovMetric Software, Inc.



Old vs. New

How Capturing and Analyzing Measurements Digitally Helps Simplify the Flange Alignment Process...and Delivers Bottom-Line Advantages

| Need/Task | Old Way | New Way | Benefits |
|------------------------------|--|---|--|
| Data Collection | Manual: Measuring flange alignment by hand is a tough slog, prone to errors and omissions. | Digital: Using the latest laser tracking and scanning devices helps automate and speed the measurements. | Measure more quickly, easily, completely, and accurately |
| Design Validation | Cross Your Fingers: Field engineers hand-measure parts and hand-modify their alignment...and hope it all works properly. | Virtual Build and Bolt: Alignment changes are fully tested and proven out in software before making them in the actual piping. | Get it right the first time |
| Project Documentation | Binders, Loose-Leaf, and Sticky Notes: Much can be lost when taking measurements and logging alignment processes manually. | Start-to-Finish Traceability: The entire project exists digitally in the point cloud. Data is precise, up to date, and comprehensive. | Repeat alignment tasks, when needed, in much less time than before |
| Process Improvement | Downtime: The piping system may need to be torn down to the smallest parts for measuring. Manual refinement and replacement can take weeks or more. | Uptime: Digital data capture and analysis is a largely “hands-off” approach. It can be done with little disruption to normal production. | Minimize shut-down time so as to optimize production yields |

Passion for Precision

Since 2005, Dimensional Engineering, Inc. has helped quality-driven engineering teams solve urgent problems by applying 3D metrology technology. The company pioneered this specialized field and is recognized worldwide as its leader.

Dimensional Engineering’s clients include the biggest names in the power and energy, process manufacturing, aerospace and aircraft, automotive, and defense industries, among others. Some include ATP Oil and Gas, Babcock Power, Boeing, Chart Energy & Chemicals, GE, General Dynamics, General Motors, Hawker Beechcraft, Honda, Hyundai, KUKA, Lockheed Martin, Maersk, Raytheon, Rolls-Royce, Siemens, Webasto, and many more.



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