

Example 1 of ACE 3T Standard Operating Procedure (Pipe Flange)

Flange Connection 3T Failure Prevention SOP with Tolerance Banding

This is an example of an Accuracy Controlled Enterprise (ACE) 3T procedure with tolerance bands to bolt together 80 NB ANSI B36.5 forged steel Class 150 flanges. Each task has a target with the allowed limits banded into 'good, better best'. Instruction is provided if the tolerance is not achieved. Please note that the example covers the method to use and is not the complete procedure.

Flange Connection Procedure

Importance of correctly mating flanges: This procedure explains how to correctly bolt-up a pipe flange on 80mm (3") diameter pipe. Leaks of dangerous chemicals from pipe flanges create a safety and environmental hazard that can lead to death of workmates and the destruction of production plant and equipment. Even a water leak from a flange causes slip hazards and makes an unsightly mess. Pipe flanges must be bolted-up so they never leak.

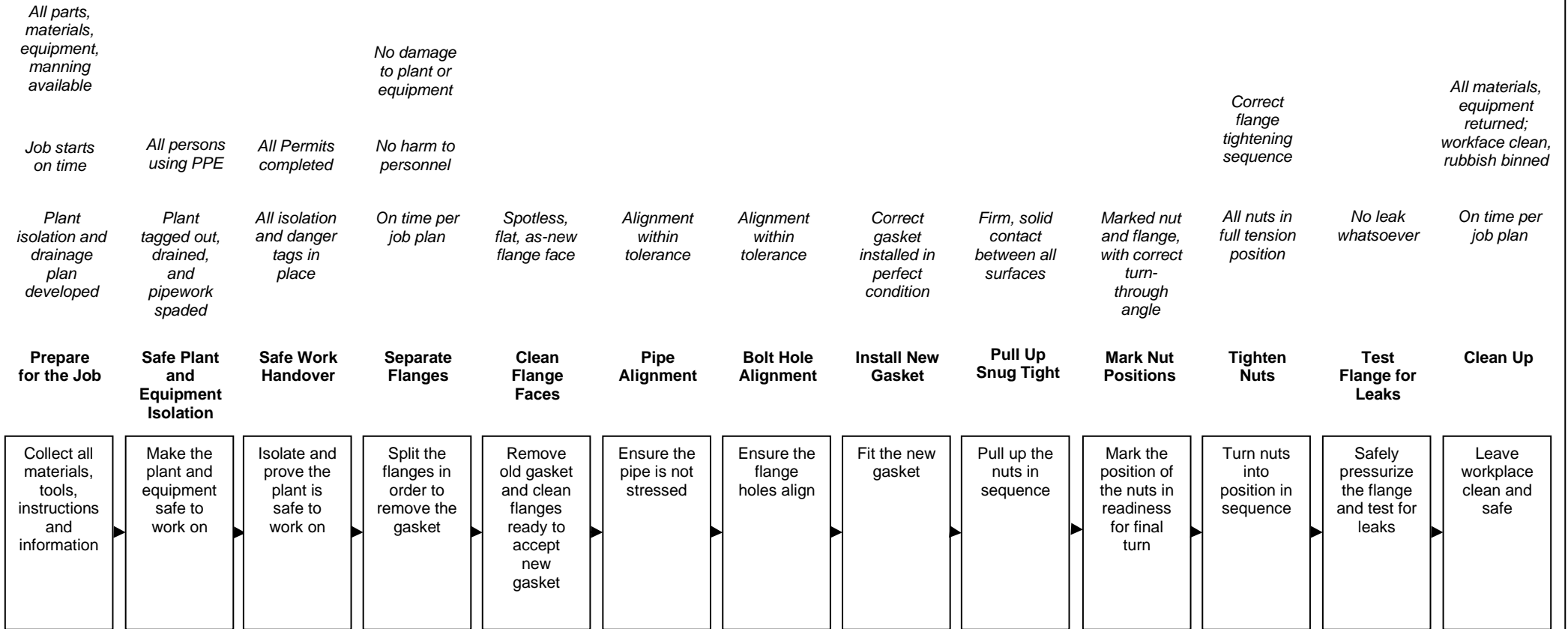
This procedure is our current best practice and you should follow it exactly. It is the result of many people's efforts over many years. It is the quickest, best way yet found to do the job right first time. Please do the job exactly as it is explained in this document. If after you have mastered this procedure exactly as it is written, you believe that you know of improvements that can be made, please bring them forward for discussion. You will be allowed to test your ideas and compare them to the procedure. If your suggestion proves to be better, it will become the new way to do this job.

Necessary Equipment and Tools: Gasket, ring spanners (adjustable shifters and pipe wrenches are not to be used as they damage corners of bolt heads and nuts making their removal dangerous and unsafe), suitably load-rated studs and nuts, pencil.

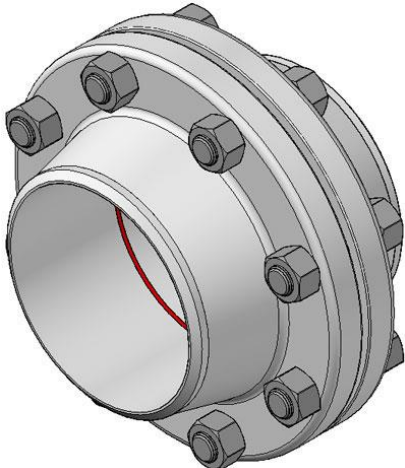
Task Summary: The process of installing gaskets and making flanges is summarized below. A detailed procedure is under the list. If an error occurs that you cannot solve please see your supervisor.

1. Get work pack, tools, NEW fasteners and NEW gasket
2. Get safe handover isolated and pipe drained
3. Place personal danger tags test if drained
4. Break and spread flange safely
5. Clean-up flange faces
6. Check unrestrained pipe alignment
7. Check bolt hole alignment
8. Mount gasket and insert fasteners
9. Pull-up fasteners snug tight in sequence
10. Mark nut position and turn angle past snug
11. Turn nuts to position in sequence
12. Test flange for leakage at operating pressure
13. Safely clean-up, hand-back, complete job record and sign-off Work Order

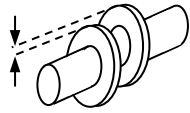
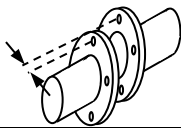
80NB Flange Gasket Replacement and Fastener Tightening Procedure



Flange Connection 3T SOP

Bolt Size	Bolt Grade	Bolt Torque	Tolerance on Torque		Engineering Standards
5/8"	A193 B7 stud and nut	201 Nm (60% Yield)	±15% with torque wrench		<u>Flange Squareness:</u> Good: Within 1 mm for every 200-mm diameter Better: Within 0.75 mm for every 200-mm diameter Best: Within 0.5 mm for every 200-mm diameter
		½ turn from snug tight	½ to 5/8 turn		<u>Stress-Free Flange Bolt Hole Alignment:</u> Good: Centers within 2 mm Better: Centers Within 1.5 mm Best: Centers within 1 mm
Gasket: Non-asbestos fiber, 1.5 mm thick, ring, grade as noted on work order					<u>Bolt Lubricant:</u> Molybdenum disulphide

Task	Task Step Owner	Task Step Name <small>(Max 3 – 4 words)</small>	Task Description	Mat'l – Tools and their Condition	Test for Correctness <small>(Include diagrams and pictures)</small>	Tolerance Bands			Reading / Result	Action if Out of Tolerance	Sign off
						Good	Better	Best			
1	Technician	Prepare for the job	Gather together NEW studs and nuts, washers gasket, thread paste, tools, job work order, danger tags, handover permit, special instructions, PPE	5/8" ring spanner or socket, podgy spike bar, screw driver, scraper	All materials and tools are on the job before starting the job	Request and collect issued items from store	Planner arranged all items ready for issue from Store	Planner has all items at job and job is ready to do		Only start work once all requirements are gathered together	
2	Technician	Inform operator	Contact Operations personnel responsible for plant isolations and handover		Handover preparation and documents correctly done	Contact Operator when ready to start job	Operator has plant off-line awaiting work	Operator has plant isolated, tagged and drained		Job can only start when Operations safely handover plant and piping	
3	Technician and Plant Operator	Make work place safe	Place personal danger tags at isolation points and accept plant handover after proving isolations and drainage	Danger Tags	Isolation procedure is correctly done and proven safe	Operator and repair man walk circuit and identify and tag isolations and open drains	Operator has isolated plant & tagged isolations out-of-service & drained piping	Operator provides isolation point drawing and walks circuit to show previous tagged isolations and open drains		Only start work when piping is fully drained and proven to be empty and possible gas build-up vented	

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4	Technician	Separate flanges	Release tension on exiting fasteners gradually in tightening sequence and then remove one fastener at a time but leaving the last fastener loosely in place if pipe springs unexpectedly, spring flanges with podgy bar	5/8" ring spanner or socket, anti-seize liquid	All fasteners removed without damage to flanges or harm to personnel or other property	Back-off all nuts half a turn in sequence and then a full turn, removing all fasteners but last one. Spring flanges with podgy	Back-off all nuts half a turn in sequence and then a full turn, catch any drops of product from flange in suitable container, remove all fasteners but last one. Spring flanges with podgy	Cover fasteners with anti-seize, back-off nuts half a turn in sequence and then a full turn, catch any drops of product from flange in suitable container, remove every second fastener and finally all fasteners but last one. Spring flanges with podgy		If flange does not spread easily review the situation and consider use of hydraulic spreader or wedges without damaging flange faces	
5		Clean flange faces	Remove old gasket and clean flange faces, remove any burrs, check face is flat with straight metal ruler and 0.05mm shim in gaps, no draw marks, pits or scratches allowed across flange face	25 mm wide metal scraper, 80 grit emery cloth	Flange face are totally clean and safely usable	Loose material removed, burr-free, flat face, no draw marks or pits deeper than 0.25mm	Grooves clean, face sanded, flat face, no draw marks or pits	Bright, smooth, flat face, no groove damage or pitting, as good as new		Replace or machine flange with identical rating and grade if pits are deep, or are in close clusters, or not flat <i>(pictures would be necessary)</i>	
6		Pipe alignment	Check unrestrained pipe alignment	5/8" ring spanner x 2, or socket and ring spanner	Measure misalignment with vernier callipers on flanges with studs removed 	Flanges are unbolted and are in-line to within 2 mm	Flanges unbolted and are in-line to within 1.5 mm	Flanges unbolted and are in-line to within 1 mm		Cut pipe and remount flange to bring unrestrained flanges to within 1 mm alignment and 0.5 mm squareness to applicable procedure for the pipe material and grade	
7	Tradesman	Bolt hole alignment	5/8" ring spanner x 2	Check bolt hole alignment	Measure with vernier callipers on flanges with studs removed 	Flanges unbolted and holes in-line to within 2 mm	Flanges unbolted and holes in-line to within 1 mm	Flanges unbolted and holes in-line to within 0.5 mm		Cut pipe and realign flange to bring hole alignment of unrestrained flanges to within 0.5 mm	
8		Install new gasket and fasteners	Mount gasket and insert fasteners. Pre-cut studs to length and de-burr so that two full threads protrude out of each nut when fully tightened. Lightly lubricate the studs and the face of the nuts in contact with the flange.	Approved NEW gasket; NEW studs and nuts, bolt lubricant, podgy bar	Only new gasket and new fastener components used	Gasket slid between flanges and centred without damage and new studs/nuts fitted by hand	Gasket slid between flanges without and centred damage and studs/nuts lightly, pre-lubricated and fitted by hand within 2 minutes	Gasket slid between flanges and centred without damage and studs/nuts lightly, pre-lubricated and fitted by hand within 1 minute			

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9		Bring flanges together	Pull-up fasteners snug tight in cross tightening sequence. Sung means flanges are in firm contact under about 20% of final bolt torque. It is obtained by the full effort of a well-built man pulling on a ring spanner until it can no longer be moved by hand. It can also be achieved by use of an impact wrench. When the spinning nut turns to blows, count three blows, and the bolt will be snug tight ¹ .	5/8" ring spanner or socket, feeler gauges	Flanges come together square with stress-free alignment	Wind nuts onto studs by hand so studs extend equal distance either side of flange. Tighten nuts finger tight and check that flanges are parallel to an accuracy of 0.4mm with the feeler gauges. Pull all nuts on both flanges up sung tight in correct sequence.	Wind nuts onto studs by hand so studs extend equal distance either side of flange. Tighten nuts finger tight and check that flanges are parallel to an accuracy of 0.2mm with the feeler gauges. Pull all nuts on both flanges up sung tight in correct sequence within 5 minutes	Wind nuts onto studs by hand so studs extend equal distance either side of flange. Tighten nuts finger tight and check that flanges are parallel to an accuracy of 0.1mm with the feeler gauges. Number the studs in the sequence of tightening. Pull all nuts on both flanges up sung tight in correct sequence within 4 minute		If flanges are not parallel, directly 180° degrees opposite widest part of indicated gap, loosen nuts off one or more turns. Return to segment with gap and tighten until both flanges are in contact with gasket. This is necessary to prevent flange levering over the fulcrum formed by the outer edge of the two raised faces at points in contact with gasket. The restriction will cause exceptionally high flange to gasket clamp loading at this point, with possible damage to gasket, PLUS diverting necessary clamp loading bolt torque energy to correcting alignment on the opposite segment.	
10		Match mark fasteners	Match-mark nut position on one flange only with a pencil when all nuts on both flanges are snug.	Pencil	Scribed marks in correct position and easily observable	Match-mark the nut and flange	Clearly match mark the nut and flange within 1 minute	Clearly match-mark the nut and flange within 45 seconds			
11		Tighten fasteners	Turn each nut on one flange only an extra 1/3 of a turn to final position in cross tightening sequence. Re-tension continuously until all nuts are equally tight. No rotation of stud is permitted while tightening the nut.	5/8" ring spanner or socket, Impact wrench	Fasteners correctly tensioned to required nut position in right tightening sequence	Tighten nuts 1/4 of a turn in cross sequence and finally tighten nuts to 1/3 of a turn in cross sequence.	Tighten nuts 1/4 of a turn in cross sequence and finally tighten nuts to 1/3 of a turn in cross sequence in 5 minutes.	Tighten nuts 1/4 of a turn in cross sequence and finally tighten nuts to 1/3 of a turn in cross sequence in 4 minutes.		If a stud starts to rotate as the nut is tightened it indicates that the nuts were not snug to start with. Immediately stop and undo all studs and repeat nut snug tensioning procedure	
12		Test for leaks	Test flange for leakage at operating pressure, release pressure and retighten nuts on same flange as originally tightened		No leak whatsoever at full operating pressure	No leak whatsoever at full operating pressure	No leak whatsoever at full operating pressure	No leak whatsoever at full operating pressure			

¹ Sheppard, Alan T., 'High Strength Bolting', The DuRoss Group, Inc.



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13		Clean and hand back	Safely clean-up, hand-back, complete job record and sign-off and record Work Order history		All equipment, tools and waste removed - area left spotlessly clean	Recommission procedure is written, reviewed and correctly done and plant proven safe for continued use	Recommission procedure is written, reviewed and correctly done and plant proven safe for continued use	Recommission procedure is written, reviewed and correctly done and plant proven safe for continued use			