



ENGINEERED PRODUCTS

**902 2nd Main Street
Elroy, WI 53929**

Operation and Maintenance / Documentation Manual

Bulk Number – 00001 thru 00012, 00014 thru 00017 & 00019
thru 00022

Vessel Serial Number – SAME AS Bulk Number

Date: 07/16/15

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Walker Stainless Equipment

Walker Stainless Equipment Company, LLC has been designing and fabricating standard and custom process and storage vessels for the food, beverage, dairy, personal care & pharmaceutical process industries for over six decades. We have worked with numerous companies to provide quality vessels for their processes.

Walker aspires to be the "best choice" for cost effective solutions and to "Meet or Exceed Customer's Expectations with Quality Products". We are confident that you will feel we have accomplished our mission with this piece of equipment.

The following is the documentation manual for your vessel.

Warranty Information

Walker Stainless Equipment Company, LLC warrants new tanks or equipment manufactured by us to be free from defects in material and workmanship under normal use and service for a period of one (1) year after shipment from the factory. For breach of warranty of any kind, the measure of damages to be recoverable from Walker shall be limited to repair or replacement of the part or equipment which examination discloses to the satisfaction of Seller to be defective, or the payment of the price of making such repair or replacement, at the option of the Seller. This warranty is expressly in lieu of all other warranties, expressed or implied, and all other obligations and liabilities on our part. Any warranty of merchantability is expressly excluded. We neither assume nor authorize any other persons to assume for us any liability in connection with the sale of our products, and no other warranty will be honored unless in writing and signed by an officer of the corporation. This warranty shall not apply to any product of our manufacture which has been repaired or altered outside our factory, or which in our opinion, has been subject to misuse, negligence or accident. Seller will not assume any charges for repairs made during warranty by anyone other than Walker. Also Seller assumes no liability or responsibility for transportation, to and from repair point, nor any loss of time due to repair. This warranty does not cover components of other manufacturers beyond such warranty as is made by such manufacturer.

Any such action for breach of warranty shall be commenced within one (1) year of said breach or be forever barred.

All information including design details and dimensions contained herein are confidential and proprietary and must not be reproduced, disclosed to others, or used in the production of parts, unless authorized in writing by Walker.

Walker Stainless Equipment, LLC has great concern for possible difficulty in paper removal (if applicable), stains, difficulty in passivation, or, any other problems that may occur with materials / finish for tank sitting at our facility, in construction areas, or that have not been placed into service within a timely manner (within a month of fabrication completion date) and will not be held responsible for these issues as conditions are beyond our control.

Walker shall not be responsible for corrosion resistance of equipment or any resulting damages. It is Customer's (Purchaser's) responsibility to specify correct material of construction specifications for the intended application(s).

#2B Mill Finish Disclaimer - Light scratches, pits, and stains are common with 2B material finish. No claims will be accepted for light defects that would typically be removed with polish process.

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ARRIVAL INSPECTION

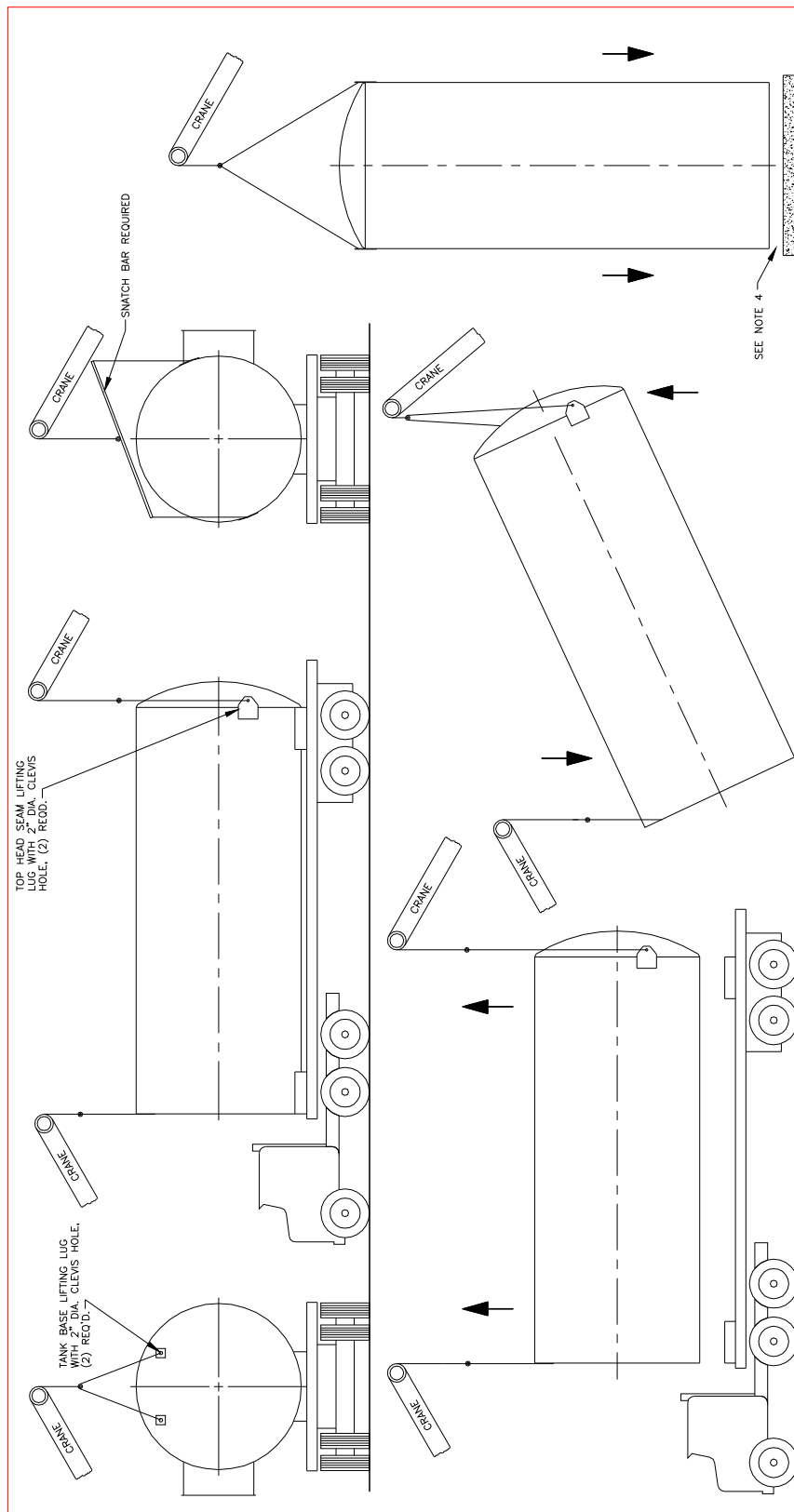
The loading of your tank at the factory has been checked and inspected, but we cannot guarantee safe, undamaged and complete arrival to your destination. Please immediately check items against the Packing List to determine that parts and accessories as listed have been received in complete and satisfactory condition. Should your inspection reveal any damage or loss, notify the freight carrier and Walker Stainless “immediately”. Tank should be inspected for road salt, grease or dirt upon arrival and removed if present.

UNLOADING

Every precaution should be taken when unloading and installing your new Walker equipment. We suggest that you review the customer approved drawing or the copies provided with this manual with your riggers and or installers, before lifting and up-righting the vessel. Caution must be used when raising the tank from a horizontal to a vertical position. Damage could result if incorrect lifting procedures are followed. (See page 7 for factory welded alcove extension or page 8 for shipped loose alcove extension).


Here are a few unloading and installation suggestions:

1. Furnish your rigger with pertinent information such as empty tank weight, and over all dimensions of the vessel so the correct moving equipment will be available.
2. The building wall should not place a load onto the alcove extension. We recommend the use of a soft gasket material or caulking next to the alcove sidewalls, and filling in the wall opening with masonry after setting the tank in place.
3. If the tank was ordered with support legs they need to be adjusted so that the vessel is level, and for equal weight distribution.
4. Avoid scratching of painted or stainless steel surfaces when lifting or moving. The use of padded cables or nylon slings is recommended to avoid such damage. Standard prime coat finishes on outer jacket should have finish paint applied as soon as possible (one week max).



NOTES:

1. ONLY LIFTING LUGS PROVIDED ON TANK. (2) LOCATED AT TOP HEAD SEAM AND (1) OR (2) AT BASE OF TANK. DO NOT USE LIFTING SADDLES AROUND SHELL OF TANK.
2. IF IT IS NECESSARY TO SET TANK OFF CARRIER PRIOR TO UPRIGHTING, USE SHIPPING SADDLES PROVIDED WITH TANK. POSITION AT ENDS OF TANK ONLY.
3. CRANE BEAMS AND (2) CRANES BE UTILIZED FOR EASE OF ERECTION.
4. CONCRETE BASE MUST BE FLAT AND LEVEL WITHIN 1/8" IF BASE FLATNESS IS IN EXCESS OF THIS TOLERANCE SHIMS MAY BE REQUIRED BETWEEN TANK SUPPORT BEAMS AND CONCRETE BASE. CHECK CONCRETE BASE FOR COMPLIANCE WITH FLATNESS TOLERANCE PRIOR TO TANK ERECTION. TANK BASE AND SUPPORT BEAMS HAVE BEEN INSPECTED PRIOR TO SHIPMENT TO INSURE THAT SUPPORT BEAMS ARE NOT DAMAGED IN TRANSIT.
5. CONSIDER TO INSURE THAT CRANES HAVE NOT BEEN DAMAGED IN TRANSIT.
6. CARRIER TO INSURE THAT CRANES HAVE NOT BEEN DAMAGED IN TRANSIT.
7. CONSULT CRANE OPERATORS AND OUTRIGGERS FOR OPTIONAL METHODS OF UNLOADING AND ERECTING.

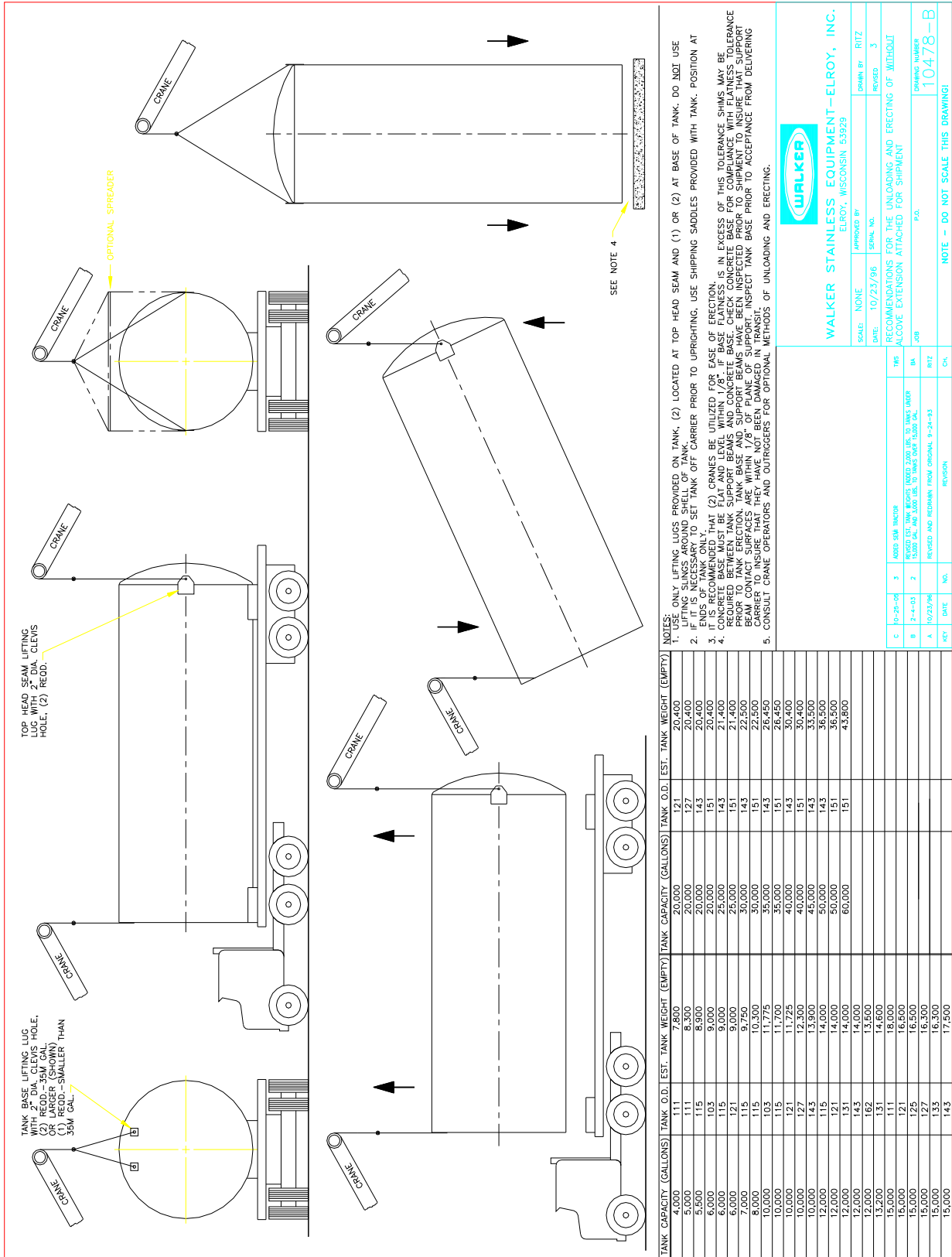
		WALKER STAINLESS EQUIPMENT—ELROY, INC. ELROY, WISCONSIN 53929	
ORDER NO. NONE		APPROVED BY	RITZ
DATE: 10/23/96	SERIAL NO.	REVISED: 4	
RECOMMENDATIONS FOR THE UNLOADING AND ERECTING OF WITH ALCOVE EXTENSION ATTACHED FOR SHIPMENT			
JOB		P.O.	DRAWING NUMBER 10478-A
1.F.	MOVED 8000 GALLON SILO	RITZ	NOTE — DO NOT SCALE THIS DRAWING!
C	ADDED SEMI TRAILER	TWS	
B	REVISED EST. TANK WEIGHTS (MOVED 2200 LBS. TO TANK UNDER 15000 GAL. AND 3000 LBS. TO TANK OVER 15000 GAL.	BA	
A	REVISED AND REPAIRMAN FROM ORIGINAL 9-24-93	RITZ	
KEY	DATE	REVISION	DCL

TANK CAPACITY (GALLONS)	TANK O.D.	EST. TANK WEIGHT (EMPTY)	TANK CAPACITY (GALLONS)	TANK O.D.	EST. TANK WEIGHT (EMPTY)
4,000	111	7,800	15,000	133	16,300
5,000	111	8,300	15,000	143	17,500
6,000	109	9,000	15,000	153	18,700
8,000	109	9,000	20,000	131	20,400
10,000	115	9,000	20,000	121	20,400
6,000	121	9,000	20,000	127	20,400
7,000	115	9,750	20,000	143	20,400
8,000	115	10,300	20,000	151	20,400
9,000	143	11,500	25,000	143	21,400

10,000	103	11,775	25,000	151	21,400
10,000	115	11,700	30,000	143	22,500
10,000	121	11,725	30,000	151	22,500
10,000	126	11,800	35,000	151	23,500
10,000	127	11,800	35,000	151	26,400
12,000	103	15,000	40,000	143	30,400
12,000	115	14,000	40,000	151	30,400
12,000	121	14,000	50,000	143	36,500
12,000	131	14,000	50,000	151	36,500
12,000	143	14,000	60,000	151	43,800
13,200	131	14,600			
14,000	143	14,200			
14,000	151	15,000			
15,000	121	16,500			
	125	16,500			
15,000	127	16,300			

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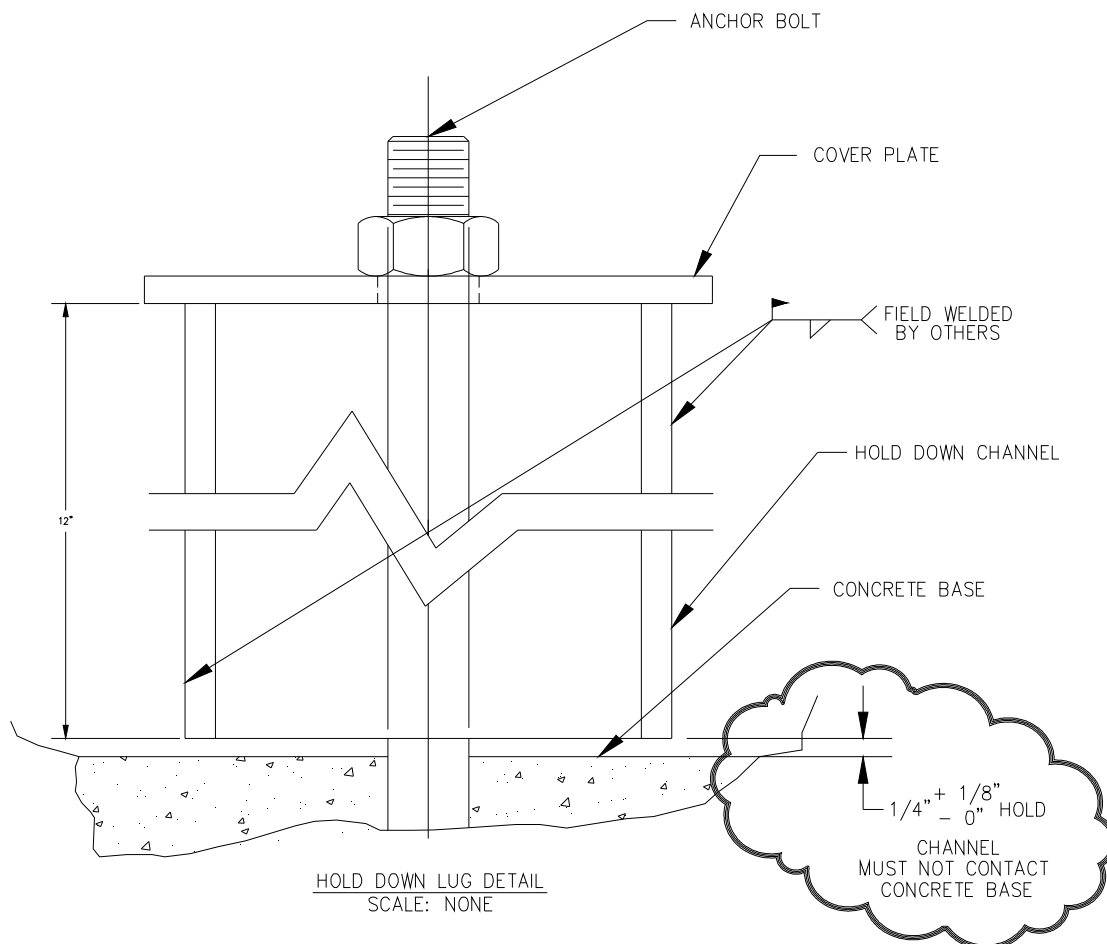
Page 7



ANCHORING SILO TANK:

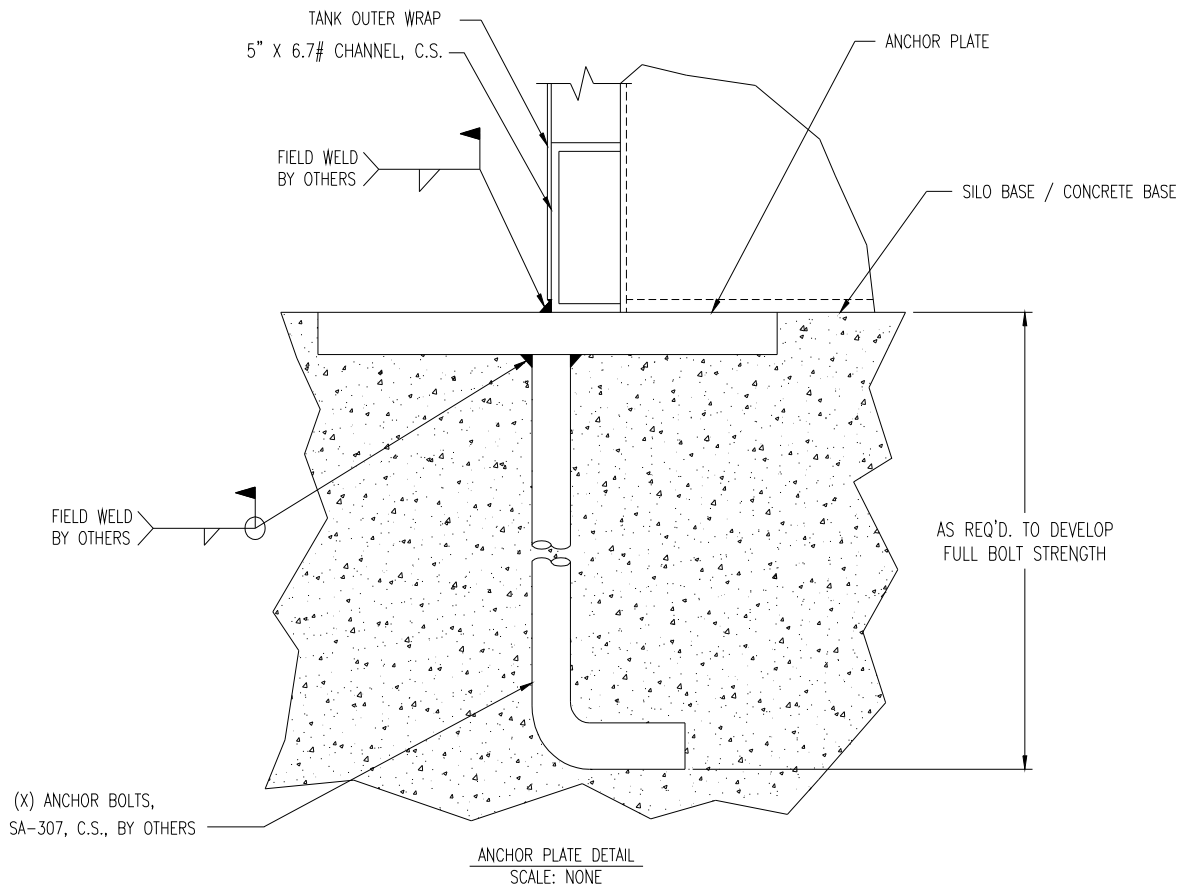
On Walker silo tanks furnished with hold down lugs / cover plates Walker furnishes a detail drawing (included with drawing approval packet) specifying recommended locations for anchor bolt size. These anchor bolts may be installed in the concrete pad prior to tank arrival or after the tank is set in place. For silos set in place prior to installing anchor bolts, use an epoxy to secure bolts in concrete.

Follow details are provided on hold down detail drawing. When installing hold down lugs ~~ ***HOLD DOWN LUGS MUST NOT CONTACT CONCRETE PAD.*** Detail drawing indicates a $\frac{1}{4}$ " distance from the bottom of the hold down lug and concrete pad.



Alternative anchoring design:

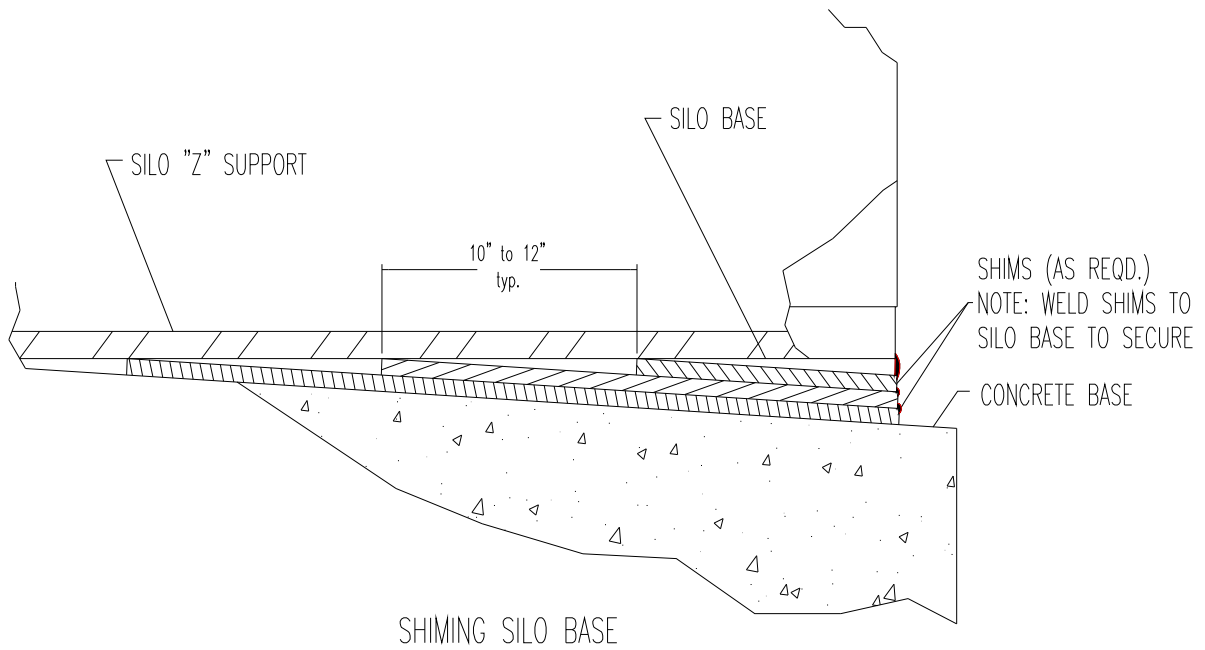
For installations where a new concrete pad is to be constructed, Walker offers an alternate design. This design consists of embedded anchor plates installed in base when concrete is poured (embeds are furnish and installed by others). As with hold down lugs, Walker furnishes a detail drawing (included with drawing approval packet) specifying recommended locations for embed plates, size and number of bolts required per embed. The embed plates should be installed at or just below the top of the finished concrete pad. **Note: Do not install embed plates above concrete pad.**



A Walker silo tank is not perimeter supported. The support comes from the “Z” channel supports located under the silo bottom. These “Z” channels run from front to back of silo and are spaced according to tank size and weight requirements.

NOTE:

CONCRETE BASE MUST BE FLAT AND LEVEL WITHIN 1/16". IF BASE FLATNESS IS IN EXCESS OF THIS TOLERANCE, SHIMS WILL BE REQUIRED BETWEEN TANK SUPPORT BEAMS AND CONCRETE BASE. CHECK CONCRETE BASE FOR COMPLIANCE WITH FLATNESS TOLERANCE PRIOR TO TANK ERECTION. TANK BASE AND SUPPORT “Z” BEAMS HAVE BEEN INSPECTED PRIOR TO SHIPMENT TO INSURE THAT SUPPORT BEAM CONTACT SURFACES ARE WITHIN 1/16" OF PLANE OF SUPPORT. INSPECT TANK BASE PRIOR TO ACCEPTANCE FROM DELIVERING CARRIER TO INSURE THAT THEY HAVE NOT BEEN DAMAGED IN TRANSIT.



IF GAP EXCEEDS 1/2" PLEASE CONTACT WALKER STAINLESS

**ALL WARNING, CAUTION, AND INSTRUCTION
DECALS LOCATED ON SILO TANK
MUST BE ADHERED TO**

**INITIAL CLEANING PROCEDURES
FOR STAINLESS STEEL EQUIPMENT**

When stainless steel processing vessels and storage equipment are shipped from the factory, a final cleaning is done to remove the manufacturing soils. No soluble oil is applied to the vessel surfaces.

During shipment and plant installation soils are deposited on both the external and internal surfaces, which must be removed before placing vessels into production. **Remove** all protective coverings (plastic, tape, etc.) that cover the Manway, Vent Screens, Fittings, etc. Then use both manual and CIP procedures for this cleaning, and inspect results.

Frequently dullness of stainless steel surfaces is the result of shipping and installation soils. When combined with food soils, this can form a film which sometimes is difficult to remove, may become unsanitary, and could cause corrosion. It is advisable to passivate the vessel(s) after cleaning.

Consult a competent chemical supplier for detailed cleaning recommendations and passivation procedure.

Chapter 2 Cleaning And Component Information

MANWAY DOOR

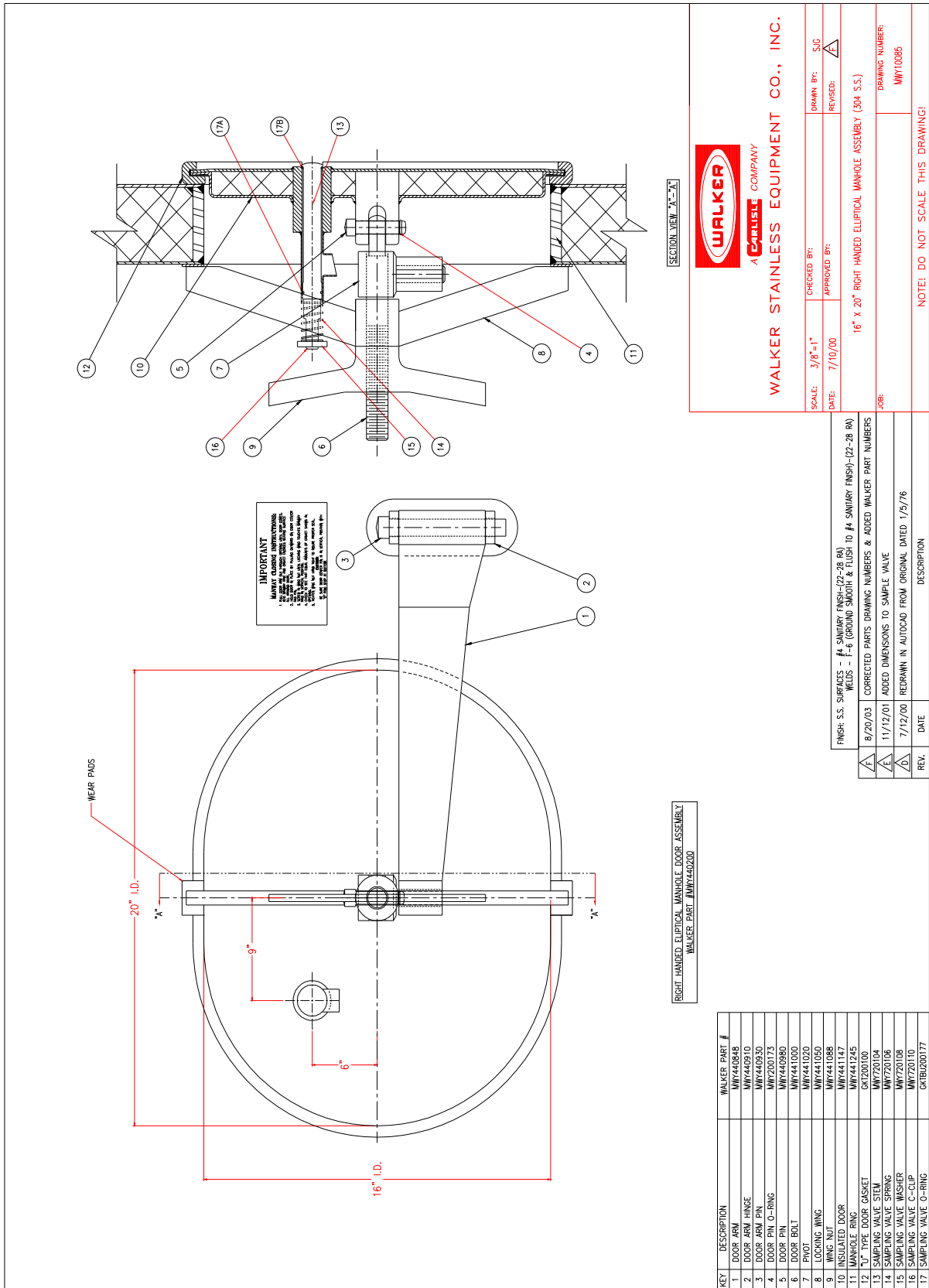
The Walker Elliptical Manway Door Assembly is opened by loosening the wingnut, and rotating the locking bar 90 degrees to the right (clockwise) to a horizontal position. Push the door inward, and invert the door so that the inside surface is facing upward and Sample Valve (if furnished) faces down and away from the opening. Carefully swing the door assembly through the opening to the outside, take care not to damage the gasket or the sealing face of the door ring.

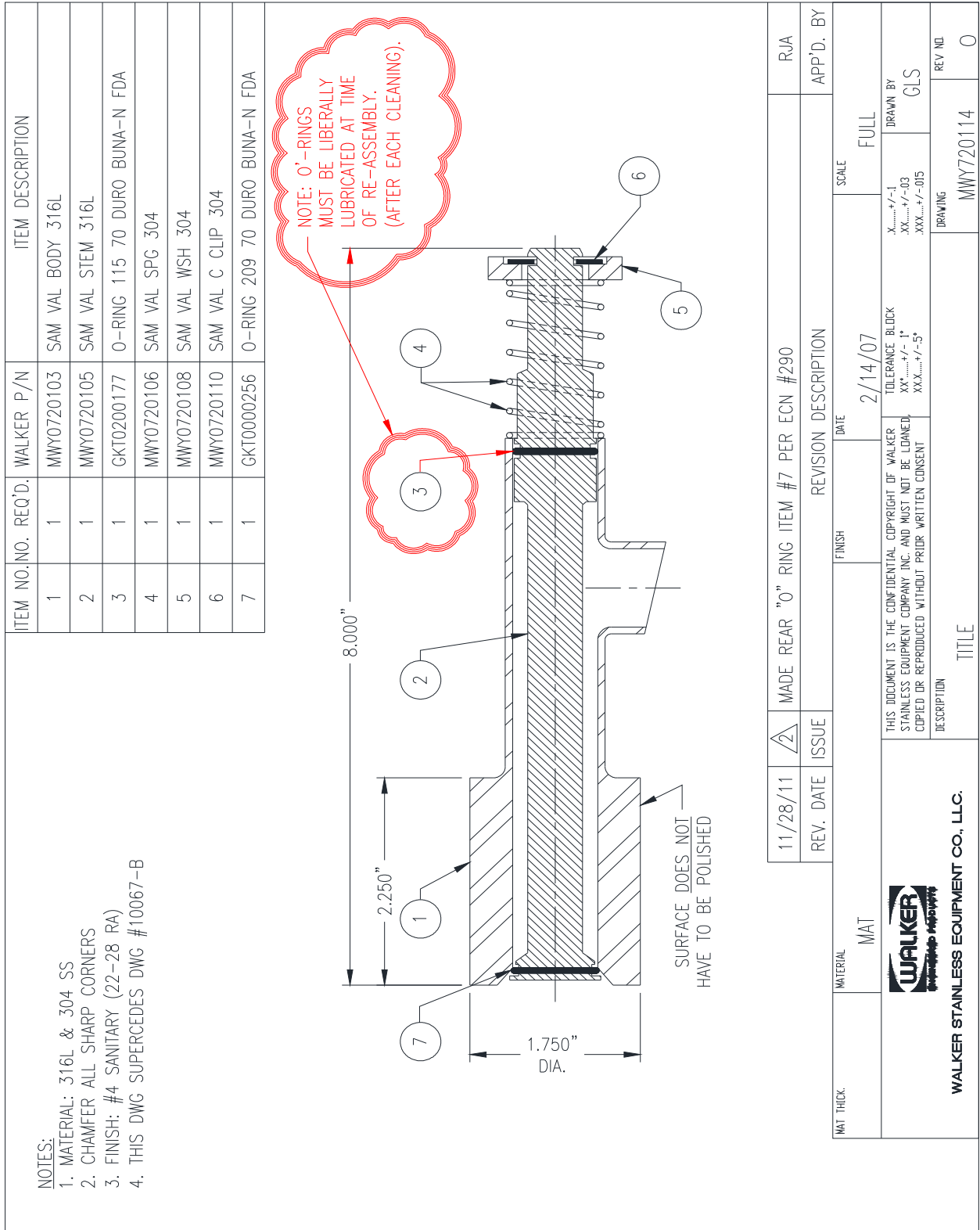
The “U” shaped Manway Gasket, Manway Door, and Sample Valve (if supplied) are to be manually cleaned.

Install the Manway Door Assembly in reverse. Be certain that the Manway Door is centered in the ring with equal amounts of gasket shown in opening. Hand tightening of the Wingnut is all the pressure that is needed to ensure a proper seal. The closing instructions label is located above the door arm hinge for your reference.

*****Note: Your Manway Door Assembly has been custom fit at the factory to ensure a proper seal, and is stamped with a serial number exclusive to your tank. You can find the number stamped on the Manway Door Center, Door Arm, and Door Ring. Please do not interchange these parts with other vessels because they are custom fit to ensure a proper seal.**

When installing the manhole gasket, stretch it over the door edge. Do not roll it on.

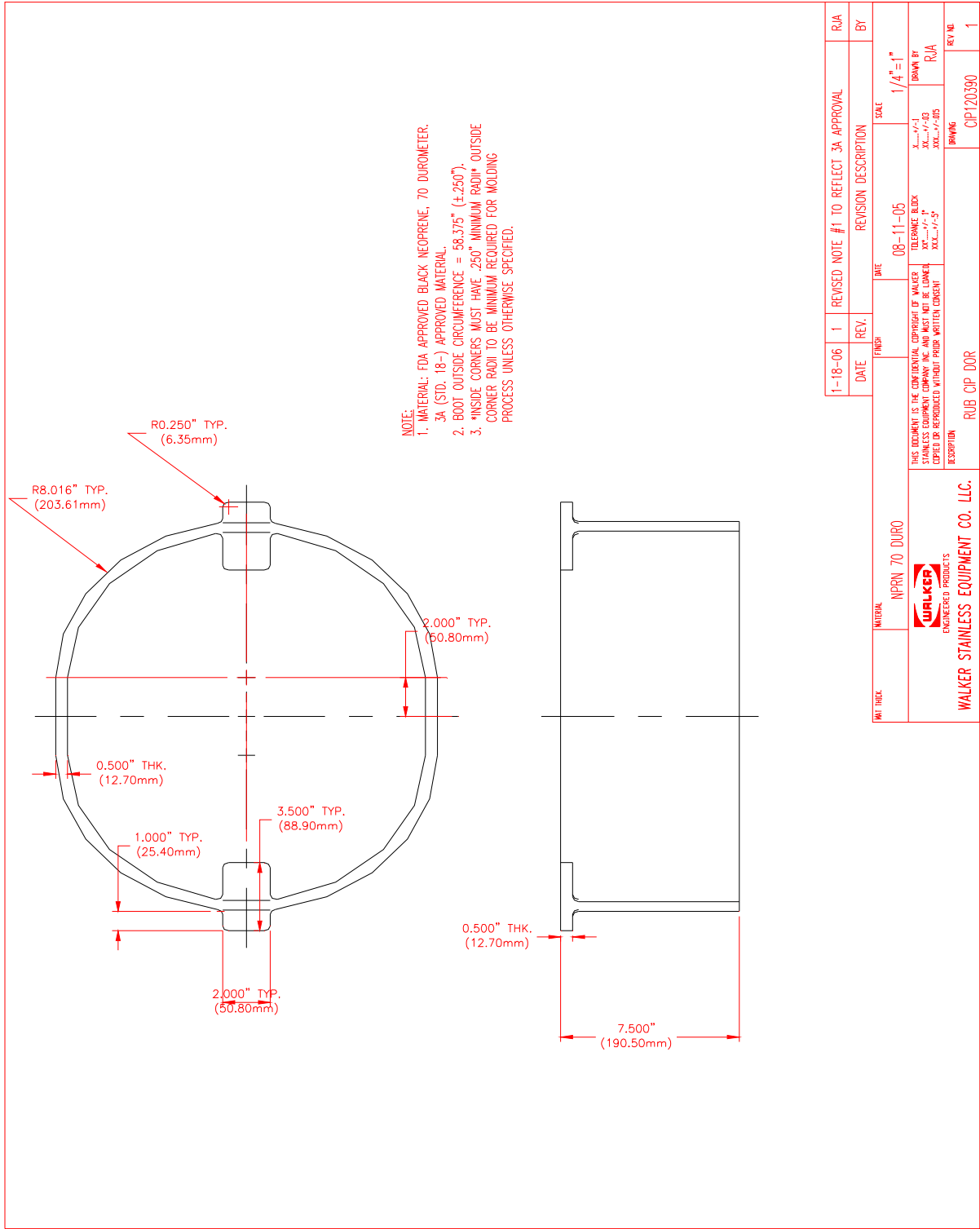




PRECAUTIONS & INSTRUCTIONS FOR USING YOUR NEW WALKER STORAGE TANK

CIP PROCEDURES:

1. Refrigerated tanks having a pressure wall jacket (coldwall) must have all liquid refrigerant removed from the pressure wall jacket prior to the application of hot pre-rinse or hot cleaning solutions. To protect against the possibility of excessive pressure deforming the coldwall surface, a #150 relief valve must be installed in the system. This is also to comply with the warranty by Walker on this equipment. The liquid refrigerant line must be closed and the compressor operating until all refrigerants has been removed from the coldwall jacket. When completely free of liquid refrigerant, there will be no cold spots on the inner surface, accumulator or connecting piping.
2. Open the Manway Door and swing it completely out of the tank per the Manway Instructions on page 13. This will allow for the large volume of heated air to escape during the cleaning cycles, and the large volume of air entering the tank during the cooling of the tank, thus preventing collapse and/or damage to the liner. **Vent Lines alone are not adequate for proper venting during the CIP procedure- the Manway Door must be open.** Hand clean the Manway Door, Door Gasket, and Sample Valve (if equipped).
3. Install the CIP Manway Door to conserve cleaning solutions.
4. Remove the Vent Screens in the Alcove and install the CIP Interlock Manifold. It is designed to catch all CIP solutions from your vent line(s) and prevent any CIP operation without the Manway being open. Note connect CIP Hose to the Agitator. The tank is now ready for cleaning.



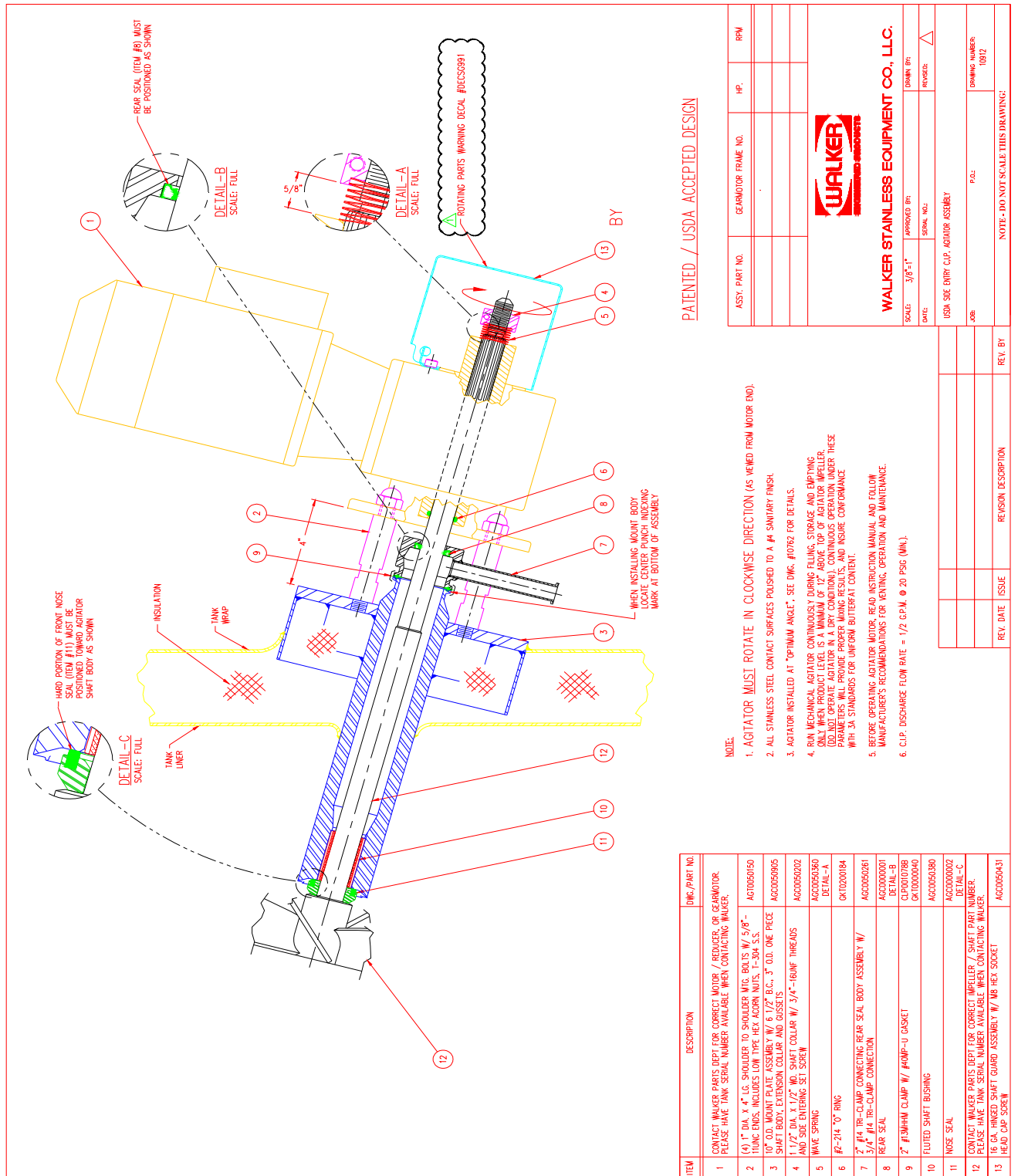
Please refer to the enclosed sheets covering cleaning of 18-8 Stainless Steel Storage and Transportation Tanks, Protecting Stainless steel Dairy Equipment From Corrosion (Life-Giving Practices).

(Applies to Silo Type Storage Tanks)

Tank damage due to vacuum being created by overfilling **will not** be warranted.

The Coldwall Surface has been tested and the design working pressure is shown on the tank nameplate. The cooling surface is thoroughly blown out by air pressure and the openings sealed until the refrigeration connections are made. Always install liquid and suction line strainers with either Ammonia or Freon refrigerants. Always install a dehydrator equal to condensing unit capacity with Freon refrigerant. Install a pressure relief valve set at 150 P.S.I.G. in the suction line between the cooling jacket and the shut-off valve. This is necessary for both safety and to comply with Walker warranty.

HORIZONTAL CIP AGITATOR



CIP AGITATOR INSTRUCTIONS

- Read these instructions completely and carefully. Call your Walker Representative with any question you may have regarding setup and or operation.

INITIAL INSTALLATION ONLY (TANKS SHIPPED WITH ALCOVE LOOSE WILL REQUIRE FIELD INSTALLATION OF ASSEMBLY): INSTALL AGITATOR GEAR DRIVE UNIT PER DRAWING UTILIZING THE SHOULDERED MOUNTING BOLTS (ITEM #2) PROVIDED. (NOTE - WHEN INSTALLING KEEP BOLTS SLIGHTLY LOOSE IN TANK MOUNT PLATE (ITEM #3) TO ALLOW GEARMOTOR ALIGNMENT). UPON COMPLETION OF INSTALLATION TIGHTEN ALL BOLTS & ACORN NUTS SECURELY.

SEE PAGE #21 TO CONTINUE WITH INITIAL INSTALLATION PROCEDURE

****INSTALLATION AND MAINTENANCE****

FOR INSTALLING OR REPLACING NOSE SEAL, SHAFT BUSHING & REAR SEAL

*LOCKOUT AGITATOR DRIVE.

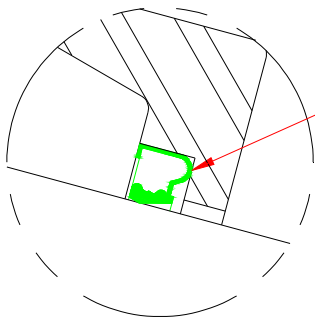
*DISCONNECT THREADED COLLAR (Item 4) ON REAR END OF SHAFT (Item 12) @ GEAR MOTOR AND REMOVE WAVE SPRING (Item 5).

*ENTER TANK AND REMOVE AGITATOR SHAFT SLOWLY INTO THE TANK.

*REMOVE WHITE FLUTED SHAFT BUSHING (Item 10) AND BLACK NOSE SEAL (Item 11).

*DISCONNECT REAR BODY (Item 7) & REMOVE WORN OR DAMAGED REAR LIP SEAL (Item 8).

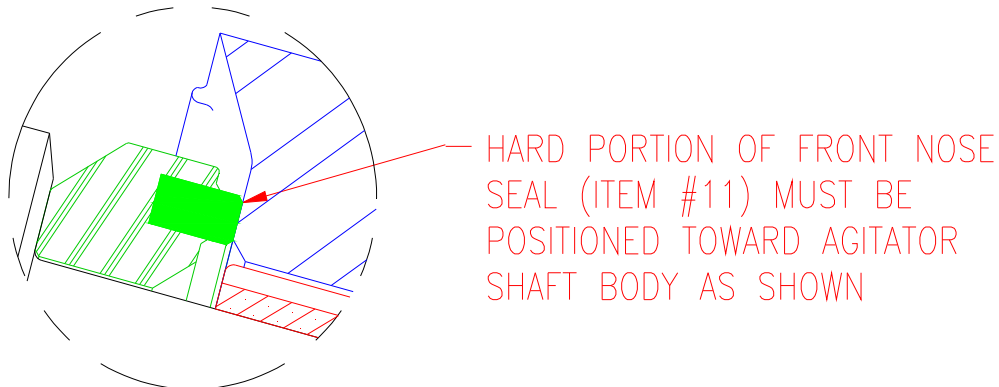
*INSTALL NEW REAR LIP SEAL UTILIZING A WALKER SEATING TOOL OR EQUIVALENT (SEAT SEAL W/ HAMMER ON SOLID SURFACE. (NOTE - SEAL IS TO BE INSTALLED WITH RUBBER LIP TOWARD TANK INTERIOR / AGITATOR BODY).



REAR SEAL (ITEM #8) MUST
BE POSITIONED AS SHOWN

PREP SHAFT BY APPLYING (FOOD GRADE) LUBRICANT LIBERALLY TO THE ENTIRE SHAFT FROM SPLINES TO IMPELLER HUB. AVOID LUBRICATING IMPELLER HUB NOSE SEAL AREA.

CAREFULLY INSTALL NEW BLACK RUBBER NOSE SEAL DOWN SHAFT TO THE IMPELLER HUB. NOTE THAT HARD END OF THE SEAL MUST FACE TOWARDS THE SHAFT SPLINES WITH THE SOFT END (RUBBER) AGAINST THE IMPELLER HUB SHOULDER. -- SEE PAGE 24 FOR NOSE SEAL REPLACEMENT



APPLY (FOOD GRADE) LUBRICANT TO THE OUTSIDE SURFACE OF A NEW WHITE FLUTED SHAFT BUSHING & INSTALL IN SHAFT BODY COUNTER BORE LOCATED IN TANK INTERIOR.

INSTALL REAR BODY WITH NEW SEAL UTILIZING THE TRI-CLAMP & GASKET. IMPORTANT NOTE – AT THIS POINT OF ASSEMBLY THE REAR HOUSING CLAMP SHOULD BE JUST TIGHT ENOUGH TO HOLD THE BODY IN PLACE YET ALLOW THE REAR BODY TO BE EASILY ROTATED MANUALLY.

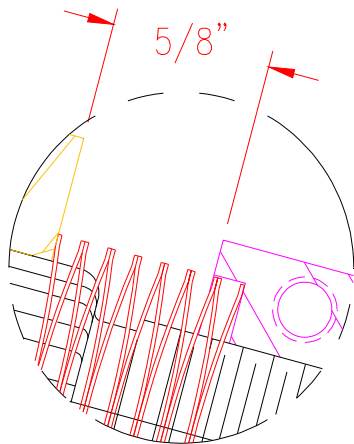
PLACE AGITATOR SHAFT WITH NOSE SEAL INSIDE TANK. ENTER TANK AND CAREFULLY GUIDE THE SHAFT THROUGH THE TANK SHAFT BODY, REAR BODY SEAL, AND ENGAGE THE SPLINES THRU THE GEAR MOTOR.

NOTE: BE SURE TO SLOWLY & CAREFULLY GUIDE THE SHAFT THRU THE AGITATOR BODY. DO NOT FORCE THINGS INTO PLACE BUT “FEEL” YOUR WAY THROUGH TO AVOID DAMAGING THE REAR SEAL WITH THE SHAFT SPLINES.

YOU MAY ALSO ELECT TO LEAVE THE REAR BODY OFF UNTIL INSTALLING THE AGITATOR SHAFT IN PLACE. THE OUTSIDE ATTENDANT WOULD THEN CAREFULLY INSTALL THE REAR BODY WHEN THE SHAFT SPLINES APPEAR THRU THE OUTSIDE END OF THE SHAFT BODY BEFORE ENTERING THE GEAR MOTOR.

WHEN INSTALLING THE SHAFT ROTATE IT SLIGHTLY TO OBTAIN SPLINE ALIGNMENT. THE SHAFT SHOULD FREELY SLIDE "AXIALLY" WHEN SPLINES ARE ENGAGED. TO TEST ALIGNMENT & INSURE PROPER FUNCTION ROTATE ENGAGED SHAFT APPROXIMATELY 90 DEGREES AND CHECK TO INSURE THE SHAFT AGAIN EASILY SLIDES AXIALLY. DO THIS FOR A COMPLETE REVOLUTION TO INSURE PROPER PERFORMANCE. IF BINDING BECOMES APPARENT AT ANY POINT, PULL BACK SHAFT AND RE-ENGAGE SPLINES AT A DIFFERENT LOCATION. REPEAT THIS STEP UNTIL SHAFT MOVES FREELY AT ALL POSITIONS.

*ON THE OUTSIDE OF THE TANK INSTALL THE WAVE SPRING AND THREADED LOCKING COLLAR TO THE END OF THE SHAFT. MAINTAIN A DISTANCE OF $\frac{1}{2}$ " TO $\frac{5}{8}$ " FROM THE COLLAR TO THE GEARMOTOR HUB & TIGHTEN THE SET SCREW. PUSH FORWARD ON THE COLLAR WITH THE HEEL OF YOUR HAND A FEW TIMES TO SEE THAT IT SLIDES IN FREELY AND QUICKLY RETURNS TO THE SEATED POSITION WHEN RELEASED.



*TIGHTEN THE REAR BODY TRI CLAMP WING NUT ONLY ENOUGH TO OBTAIN A SEAL. OVER TIGHTENING COULD RESULT IN REAR SEAL MISALIGNMENT.

*AGITATOR ASSEMBLY IS NOW READY FOR OPERATION.

****IMPORTANT MAINTENANCE NOTES****

****** DO NOT RUN AGITATOR ASSEMBLY WITHOUT SHAFT GUARD ASSEMBLY (ITEM #13) PROPERLY INSTALLED. ******

*DO NOT RUN AGITATOR ASSEMBLY DRY (NOT SUBMERGED IN PRODUCT). PREMATURE FAILURE OF SHAFT BUSHING AND NOSE SEAL WILL OCCUR.

*DO NOT RUN AGITATOR ASSEMBLY UNTIL PRODUCT LEVEL IS APPROXIMATELY 10" ABOVE TOP OF AGITATOR IMPELLER. FAILURE TO DO SO WILL RESULT IN AN UNEVEN LOAD ON GEARS CAUSING GEARMOTOR DAMAGE / FAILURE.

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*C.I.P. SYSTEM MUST BE FREE OF OBSTRUCTIONS AS THESE PARTICLES CAN LODGE IN BUSHING AND SEAL AREAS CAUSING DAMAGE.

*FAILURE TO SET UP A PREVENTIVE MAINTENANCE SCHEDULE COVERING AGITATOR PARTS WILL CAUSE IRREPARABLE DAMAGE TO THE AGITATOR BODY. WALKER RECOMMENDS THAT PARTS BE INSPECTED A MINIMUM OF ONCE A MONTH. CRITICAL WEAR PARTS INCLUDE NOSE SEAL (Item 11), FLUTED SHAFT BUSHING (Item 10), AGITATOR SHAFT (Item 12) AND REAR SEAL (Item 8). HOWEVER, ENTIRE ASSEMBLY MUST BE INSPECTED / MAINTAINED.

*BE SURE TO LUBRICATE SHAFT AT EACH INSPECTION.

C.I.P. OPERATING INSTRUCTIONS:

The Walker CIP Agitator provides pressurized cleaning of the Agitator Blades and nose sealing surfaces during normal tank CIP operations. The Agitator Drive "MUST" be operated throughout the CIP cycle. The system will operate properly at any supply pressure normally appropriate for tank cleaning. Minimum 20 P.S.I.G. @ flow rate of approximately @ ½ GPM, without back flow or waste solution.

MAKING THE CIP CONNECTION: The CIP Agitator Supply Hose is furnished as part of the CIP Piping Interlock. The end of this hose attaches readily to the Tri-Clamp connection on the Rear Seal Body Assembly (item #7), and must be connected before the CIP cycle begins.

CIP OPERATION: Perform CIP cycle in accordance with your operating procedures. Spring loading at the rear of the Agitator Shaft allows CIP solution to pass by the front seal and spray onto the impeller without need for manual adjustment.

AFTER CIP OPERATION: Upon completion of the CIP cycle, the supply hose must be disconnected from Rear Seal Body. Note: The operator will need to allow agitator to run an additional 30 seconds after C.I.P. cycle to ensure seating of the nose seal, or, **shut off gearmotor** and raise the Shaft Guard (item #13) at the rear of the assembly and pull back on the Shaft Collar to ensure that the Nose Seal is reseated. This will prevent product leakage prior to Agitator start-up.

NOSE SEAL REPLACEMENT PROCEDURE

1. Lift the guard and loosen the allen set screw on the side of the shaft collar. Remove the shaft collar and wave spring from the threaded end of the agitator shaft.
2. From inside of the tank, pull the agitator impeller out of the body assembly.
3. Inspect the machined surface on the body assembly for excessive wear.
4. Install the new nose seal on the agitator shaft making sure the rubber end goes on first and the carbon face of the seal rides against the machined face on the body assembly.
5. Gently reinsert the agitator shaft into the housing. Do this slowly, so as not to damage the rear seal. Rotate the agitator impeller as need to engage the splines in the rear spline drive bushing.

Place the wave spring over the end of the shaft and screw on the shaft collar. Tighten the shaft collar until a 5/8" gap remains between the shaft collar and the rear gearbox bushing. Note: under-tightening the shaft collar to impeller shaft can result in product leaking past the nose seal. Over-tightening can result in damage to the nose seal and excessive part wear.
6. Tighten the allen head set screw on the side of the shaft collar to lock in the 5/8" setting.

Walker CIP Agitator Trouble Shooting Guide

SYMPTOM

Inadequate Cleaning of Blades or Chamber

1. Shaft collar not adjusted properly. Decrease tension on spring (Reference Drawing for starting point).
2. Failure to rotate Agitator Drive during CIP cleaning.
3. Chamber/Passage clogged with CIP debris. Remove debris. Consider adding a prefilter to the system.
4. Inadequate supply pressure and or volume.

CIP Solution leaks at Rear Seal Body

1. Rear Seal is worn or damaged, inspect/replace Rear Seal.
2. Shaft badly scored at seal point. Possible bent shaft. Replace Shaft and Rear Seal.

Product Leaks

1. Nose Seal not seated after CIP- bump on the Shaft Collar (item #4). Slight leak may continue until chamber drains completely.
2. Upon C.I.P. operation completion, run agitator assembly an additional 30 seconds to assure seating of nose seal.
3. Replace Nose Seal Item #11

***PROTECTING STAINLESS STEEL DAIRY EQUIPMENT
FROM CORROSION***

*Installation and Maintenance Cleaning
and
“Life-Giving” Practices*

Published by

***NATIONAL ASSOCIATION OF DAIRY AND
FOOD EQUIPMENT MANUFACTURERS
Washington, D.C.***

Close observance of the practices and recommendations for installation, maintenance, cleaning, and bactericidal treatment of stainless steel equipment stated herein, will result in longer, corrosion-free life for your equipment and should provide a clean, sanitary surface for milk and milk products. Such practices and recommendations are consistent with the provisions of the United States Public Health Service Recommended Milk Ordinance.

NICKEL BEARING STAINLESS STEEL (AISI 300 Series) is resistant to corrosion by milk and other products, that is, under normal operation the milk and other dairy products that come in contact with the stainless steel will not cause corrosion. However, since the advent of circulation cleaning and C.I.P. procedures, corrosion problems in dairy plants have been aggravated.

Nickel bearing stainless steel is the best material known to dairy equipment manufacturers for the construction of dairy equipment, but the following procedures must be followed in order to insure preservation of the surfaces of stainless steel equipment.

INSTALLATION AND MAINTENANCE OF STAINLESS STEEL DAIRY EQUIPMENT

Instructions:

1. The use of dissimilar metals should be minimized in the fabrication of the product contact surfaces, especially if the equipment is to be placed in a C.I.P. type installation. Wherever possible, use only "AISI 300 Series" stainless steel. "WhiteMetal", a copper-nickel alloy, should not be used in fabricating product contact surfaces. If possible, "AISI 400 Series" stainless steel should not be used with "AISI 300 series" in fabricating a product contact surface, especially if the equipment is to be used in a C.I.P. type installation.
2. Stainless steel tubing should be insulated from metal pipe hangers with non-absorbent insulation.
3. Gaskets should be non-absorbent materials that are free from iron oxide or other corrosive substances.

Reasons:

1. The use of dissimilar metals, even two different series stainless steels, or “White Metal” for product contact surfaces in the same system may result in discoloration, pitting, or etching.
2. Failure to insulate may result in galvanic or other types of electrolytic corrosion with serious damage to the piping. Absorbent insulation may accumulate moisture and aid in the corrosion of the piping.
3. Chemically active gasketing material may induce corrosion.

Instructions:

4. Leaky gaskets and joints should be promptly replaced or repaired. The use of different types of fittings in making pipe connections should be avoided, where possible. Properly designed and installed pipe and equipment supports and mountings are necessary to prevent undue mechanical strains and stresses on joints.
5. Welding and polishing should be performed by competent individuals using approved methods and materials. The use of low welding temperatures, appropriate grades of welding rod and parent metal, and iron free polishing wheels and compound is encouraged. Excessive grinding and polishing can leave the surface(s) in a weakened condition.
If any question exists as to the quality of the finished weld and polish, appropriate quality checks such as X-ray or dye-check should be used.
6. When new equipment, and particularly C.I.P. systems are installed, all electrical equipment in the area of the installation should be checked for proper connections, grounding, worn or damaged insulation, or other factors that might lead to stray electrical currents. Periodic “preventive maintenance” checks should be made to insure that this condition does not occur.
7. When installations is complete, and prior to use, the equipment and piping should be thoroughly cleaned, drained, and allowed to air dry, if possible. It should then be subjected to an approved bactericidal treatment just before product is to be processed.

Reasons:

4. Product and cleaning material leaking through joints may promote corrosion if the corrosive material is allowed to remain in the joint area. C.I.P. Installations, where lines are not normally dismantled, are especially susceptible to corrosion in the joint area if leaks occur.
5. The corrosion resistance of even the highest grades of stainless steel may be reduced considerably by the use of excessive welding heat. By the use of low grade welding rod or parent metal; by the incorporation of iron particles during polishing; or from failure to remove weld spatter or fluxing agents.

Pits or voids remaining in the polished weld area should be completely removed since they form natural areas for corrosion to start.
6. A pitting form of corrosion may result if stray electrical current comes in contact with moist stainless steel. Local electrical power companies or electricians should be consulted with regard to detection of such a condition.
7. Thorough cleaning and air drying permits the formation of a protective oxide film, which is the key to placing the system in its most corrosion resistant (passive) condition.

CLEANING AND BACTERICIDAL TREATMENT

Instruction:

1. Use only products of reputable and responsible chemical manufacturers who are familiar with dairy processing equipment processes and limitations, and who are able and willing to make specific recommendations for cleaning practices.
2. Use the manufacturer's products in the precise manner in which they are recommended, but only with the concurrence of the equipment manufacturer.
3. Use a suitable water conditioner if the water supply is contaminated with foreign matter which may cause discoloration of the metallic surfaces or undesirable deposits.

4. When product processing has been completed, the heat transfer surface should be emptied (if included), and C.I.P. door immediately installed and then the equipment should be rinsed with warm water until the rinse water is clear. Complete circulation or manual cleaning should follow as soon as possible.
5. Use only soft non-metallic brushes, sponges, or pads, when manual cleaning is indicated. An extended period of soaking in the cleaning solution will facilitate removal of stubbornly adhering residues. Extreme care is required when manually brushing to avoid scratching the surface of stainless steel equipment.

Reasons:

1. Responsible chemical manufacturers continuously check the results obtained with their products on dairy processing equipment, and maintain technically qualified staffs of service personnel.
2. Misuse of normally acceptable cleaning and bactericidal products, in excessive concentrations, temperatures, or exposure times, may cause permanent damage to processing equipment.
3. Deposits or discoloration from a contaminated water supply may counteract the best cleaning practices, and may cause corrosion of the best quality stainless steel equipment.
4. Product deposits are most easily removed while still moist, and considerable amounts of soil can be removed by the initial rinse following processing. Particles of moist soil left on the stainless surfaces may cause pitting at a point beneath the particle.
5. Metal brushes or sponges will scratch the surface of stainless steel equipment and may promote corrosion over an extended period of time. If improperly used, even non-metallic brushes may scratch the surface. Metallic particles from sponges, if allowed to remain on equipment or in pipelines, may cause corrosion.

Instructions:

6. If alkaline and acid cleaners are used alternately in circulation cleaning, one must be completely rinsed out before the other is introduced into the system. After chemical circulation has been completed, the system must be thoroughly rinsed with warm water, then cool water, before it is shutdown. Whenever possible, the

system should be completely drained and opened to allow the metallic surfaces to air dry, so that the corrosion resisting passive film (oxide) may form.

7. Bactericidal treatment with “live steam” is many times only partially effective, and may cause considerable damage to processing equipment. It is not to be recommended.
8. When chemical bactericides are used, extreme caution must be exercised to use them only as prescribed by the chemical manufacturer, in concurrence with the local health authorities and the equipment manufacturer. Specific concentrations, temperatures, and exposure times must be followed as recommended. In addition, the chemical bactericide should be applied just before the equipment is to be used, and in no case should the exposure time exceed twenty (20) minutes.
9. If it is impossible to replace “White Metal” and “AISI 400 Series” stainless steel components from processing systems that are to be circulation cleaned, these parts should be removed from the system during the cleaning cycle and manually brushed, if at all possible.

Reason:

6. If alkaline cleaning solutions and milk residues are not completely removed, a “milkstone” build-up may occur. If acid solutions are not completely removed, a highly corrosive atmosphere may form which can cause discoloration or pitting. In addition, most chemical bactericides are considerably more corrosive if they are introduced into an acidic medium. A thorough final rinse is of major importance in the prevention of corrosion.
7. Concentrated heat may cause buckling, erosion, or discolorations of stainless steel, and may reduce corrosion resistance in localized areas.
8. Excessive concentrations, exposure times, or temperatures employed during bactericidal treatment with chemicals may cause serious corrosion of the metal surface and premature aging of the sanitary rubber parts in the system.
It should be noted that even a few degrees increase in the temperature at which the chemical bactericide is applied would greatly increase the chemical activity, and thus the corrosive effect upon the metallic surfaces and the aging effect upon the rubber

9. “White Metal” and “AISI 400 Series” stainless steels are considerably less resistant to chemical attack than the “AISI 300 Series” stainless steel, and they may be readily corroded when cleaned by circulation methods.

“LIFE-GIVING” PRACTICES

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Heat Tape & Insulation On C.I.P. And Vent Piping:

If Applicable ~~

Silo tanks located in cold weather climate where temperatures drop to or below the freezing mark must be furnished with heat tape and insulation on the C.I.P. and vent piping to prevent lines from freezing.

Condensation forming on the inside of the C.I.P. and vent line(s) may / will freeze thus restricting venting capability to the silo. Tank damage will occur once vent line(s) are restricted to the point they can no longer supply inside tank with enough air to compensate for product fill / empty rate thus causing tank damage due to pressure or vacuum.

Standard Silo Tanks are designed for – ***Atmospheric Pressure***

Chapter 3 Equipment Safety Recommendations

Equipment Safety Recommendations

General Operating Safety

- Do not operate this machine until you read and understand the operating instructions and become thoroughly familiar with the machine and its controls.
- Never operate a machine while a safety device or guard is removed or disconnected.
- Always wear safety glasses, hats, shoes, ear protection or any other required safety equipment.
- Never remove “Warnings” that are displayed on the machine. Torn or worn labels should be replaced.
- Do not start the machine until all other personnel in the area have been warned and have moved outside the operating zone.
- Remove any tools or other foreign objects from the operating zone before starting.
- Absolutely do not have loose clothing, neckties, necklaces or unrestrained long hair near an operating machine.
- Do not wear gloves, rings, watches, bracelets or other jewelry near an operating machine.
- Keep the operating zone free of obstacles that could cause a person to trip or fall towards an operating machine.
- Never sit or stand on anything that might cause you to fall against the machine.
- ‘Horseplay’ around a machine at any time is dangerous and prohibited.

- Know the EMERGENCY STOP procedure for the machine.
- Air, hydraulic and electrical power must be off when the machine is not in use. **Note: For maximum protection, the power source should be locked out using a lock for which only you have the key. This prevents anyone from accidentally turning on the power while you are servicing the machine.**
- Never operate the machine above specified speeds, pressures or temperatures.
- Never manually operate limit switches with power on.
- Keep alert and observe indicator lights and warnings that are displayed on the machine.
- Never leave the machine unattended while in operation.
- Do not operate faulty or damaged equipment. Make certain proper service and maintenance procedures have been performed.
- Avoid placing fingers, hands, or any part of your body into the machine or near moving parts when control circuits are energized.
- A safe work surface should be provided, including proper guarding of platform areas and the design and use of ladders.

SPECIAL NOTE - All installation, service, maintenance and operations must be performed in strict accordance with OSHA's Standard for Control of Hazardous Energy (lockout/tagout) 29 CFR 1910.147.

Confined Space Safety

- Entering any area which meets the definition of a confined space may create a serious hazard for a worker.
- All maintenance and service procedures must be performed in strict accordance with OSHA standard #1910.146 (permit required confined space).

Pressurized System Safety –

HEAT TRANSFER SURFACE

(If Provided)

- Never operate a pressurized system unless covers, safety devices and indicators are operating and in place.
- Never operate a pressurized system above the pressure specified.
- Never loosen any fittings/connections when the system is under pressure.
- Never operate a machine that has leaks in the system.
- A pressurized system can retain pressure even after the power is off. Care is required to avoid injury.

Electrical Safety

- All electrical/electronic maintenance and service should be performed by trained and authorized electricians only.
- Always assume that power is on and treat all conditions as live. This practice assures a cautious approach which may prevent an accident or injury.
- To remove the load from circuit or equipment, open disconnect or breaker and lock in open position. **Note: For maximum protection the power source should be locked out using a lock for which only you have the key. This prevents anyone from accidentally turning on the power while you are servicing the machine.**
- Make certain that the circuit is open by using the proper test equipment. Note: Test equipment must be checked at regular intervals.
- Capacitors must be given time to discharge, otherwise it should be done manually with care.
- There may be circumstances where “trouble-shooting” on live equipment may be required. Under such conditions, special precautions must be taken as follows:

- Make certain your tools and body are clear of the ground
- Extra safety measures should be taken in damp areas.
- Be alert and avoid any outside distractions.
- Before applying power to any equipment, make certain that all personnel are clear of the machine.
- Control panel doors should be open only when checking out the electrical equipment or wiring. After closing the panel door, make certain that (on those panels where applicable) the disconnect handle mechanism is operating properly.
- All covers on junction panels should be closed before leaving any job.
- All electrical apparatus must be properly grounded and overload protected.
- All electrical connections should be protected by confining them within a sealed junction box.

Service and Maintenance Safety

- Do not service a machine until you are thoroughly qualified and familiar with the tasks to be performed.
- Never operate any controls while other persons are performing maintenance on the machine
- Do not bypass a safety device.
- Always use the proper tool for the job.
- Never open covers that house electrical components when the power is on.
- Only perform maintenance on a machine in motion when properly trained and required to do so. When directed to make adjustments on machines in motion, extreme care must be taken.
- All air and hydraulic pressure must be relieved before performing maintenance or loosening connection on any pressurized system.

- Air, hydraulic and electrical powers are to be turned off unless they are absolutely required for the specific servicing being performed. **Note: For maximum protection the power source should be locked out using a lock for which only you have the key. This prevents anyone from accidentally turning on the power while you are servicing the machine.**
- Replace fuses only when electrical power is off (locked out).
- Do not enter a confined space without first checking for toxic fumes and providing standby personnel on the site.

Thermal Shock Loading

Direct expansion of stainless steel is approximately 9.6×10^{-6} inches/inch/temperature differential. This rapid expansion rate, if not controlled, will be detrimental to the weld or material integrity of the vessel and may cause shock loading with results of eventual metal fatigue.

Shock loading is very easy to detect. Especially when the tank begins to make rapid expansion noises (crackling, popping, or hammering sounds). In a heat exchange system these sounds can also occur if air, etc... is not purged before use.

To prevent Shock Loading, whether it be a heat exchange surface or a tank, we recommend not exceeding a 50 F temperature differential when cooling, heating, or cleaning (CIP).

It has been noted, when cooling, that some manufacturers will use tempered solutions while others will allow time for the tank to cool by itself. Both procedures are effective for prevention of shock loading.

A gradual rise or reduction in metal temperature will afford maximum longevity of material.

Chapter 4 General Information

Common Options.

- 1) If your tank is equipped with heat transfer surface, a relief valve (typically NOT supplied by Walker) must be installed on the inlet with a rating not greater than the jacket rating on the nameplate. The sizing of this valve must include consideration for over pressurization by thermal expansion and/or any mechanical means possible in the system in which the heat transfer surface is installed.

If this vessel is refrigerated by direct expansion, DO NOT use water at temperatures higher than 115 Deg. F. because of danger of developing high refrigerant pressures.

- 2) If your tank is equipped with C.I.P. sprayballs, caution must be used when introducing hot cleaning solution into a cold tank. There is potential for vacuum damage to the tank (manway door must be open during C.I.P. operation) and pressure damage to the cooling surface.
- 3) If your tank is equipped with insulation and sheathing, a weep hole with a plastic plug has been provided in the tank bottom to allow the insulated area to breathe. This vent should be checked periodically to make sure that it is clean and free of debris. If you notice product or water flowing from this vent plug, call the factory as soon as possible.

Additional Cleaning Recommendations

Things To Do	Things <u>Not</u> To Do
Contact a competent chemical supplier for detailed cleaning recommendations and passivation procedure**	Remove any placards, labels or other identification markings.
Refer to manufacturer's information for the proper use, care and maintenance of all components.	Wear rings, jewelry or other sharp objects when entering the vessel.
Wear appropriate personal protective equipment for the environment in which you are working.	Use abrasive cleaners on viewing windows or panels.
Use proper safety precautions (as recommended by the manufacturer) when handling sanitization or cleaning agents.	Use steel wool as particles may become imbedded in the surface and develop rust.
	Use water high in iron, salt, or sulphur
	Allow foreign matter to adhere to tank
	Allow rubber or metal parts, wrenches, or fittings to rest on wet stainless steel surfaces as this excludes air and prevents drying
	Allow bactericides or cleaners to remain on surfaces for over 20 minutes
	Use chemical bactericides or cleaners in excess of manufacturer's instructions as it wastes material and may cause corrosion
	Apply pressure in tank unless designed for such services
	Use chlorinated solvents on stainless steel surfaces.

** Walker highly recommends an onsite passivation prior to placing equipment into service.

Material Data Sheet: Stainless Steel 304 and 304L

Chemical Formula

Fe, <0.8% C, 17.5-20% Cr, 8-11% Ni, <2% Mn, <1% Si, <0.045% P, <0.03% S

Background

Grade 304 is the standard "18/8" stainless; it is the most versatile and most widely used stainless steel, available in a wider range of products, forms and finishes than any other. It has excellent forming and welding characteristics. The balanced austenitic structure of Grade 304 enables it to be severely deep drawn without intermediate annealing, which has made this grade dominant in the manufacture of drawn stainless parts such as sinks, hollow-ware and saucepans. For these applications it is common to use special "304DDQ" (Deep Drawing Quality) variants. Grade 304 is readily brake or roll formed into a variety of components for applications in the industrial, architectural, and transportation fields. Grade 304 also has outstanding welding characteristics. Post-weld annealing is not required when welding thin sections.

Grade 304L, the low carbon version of 304, does not require post-weld annealing and so is extensively used in heavy gauge components (over about 6mm). Grade 304H with its higher carbon content finds application at elevated temperatures. The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures.

Key Properties

These properties are specified for flat rolled product (plate, sheet and coil) in ASTM A240/A240M. Similar but not necessarily identical properties are specified for other products such as pipe and bar in their respective specifications.

Composition

Typical compositional ranges for grade 304 stainless steels are given in table 1.

Table 1. Composition ranges for 304 grade stainless steel

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	N
304	min.	-	-	-	-	-	18.0	-	8.0	-
	max.	0.08	2.0	0.75	0.045	0.030	20.0	-	10.5	0.10
304L	min.	-	-	-	-	-	18.0	-	8.0	-
	max.	0.030	2.0	0.75	0.045	0.030	20.0	-	12.0	0.10
304H	min.	0.04	-	-	-	-	18.0	-	8.0	-
	max.	0.10	2.0	0.75	0.045	0.030	20.0	-	10.5	-

Mechanical Properties

Typical mechanical properties for grade 304 stainless steels are given in table 2.

Table 2. Mechanical properties of 304 grade stainless steel

Grade	Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
				Rockwell B (HR B) max	Brinell (HB) max
304	515	205	40	92	201
304L	485	170	40	92	201
304H	515	205	40	92	201
304H also has a requirement for a grain size of ASTM No 7 or coarser.					

Physical Properties

Typical physical properties for annealed grade 304 stainless steels are given in table 3.

Table 3. Physical properties of 304 grade stainless steel in the annealed condition

Grade	Density (kg/m ³)	Elastic Modulus (GPa)	Mean Coefficient of Thermal Expansion (µm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0-100°C (J/kg.K)	Electrical Resistivity (nΩ.m)
			0-100°C	0-315°C	0-538°C	at 100°C	at 500°C		
304/L/H	8000	193	17.2	17.8	18.4	16.2	21.5	500	720

Grade Specification Comparison

Approximate grade comparisons for 304 stainless steels are given in table 4.

Table 4. Grade specifications for 304 grade stainless steel

Grade	UNS No	Old British		Euronorm		Swedish SS	Japanese JIS
		BS	En	No	Name		
304	S30400	304S31	58E	1.4301	X5CrNi18-10	2332	SUS 304
304L	S30403	304S11	-	1.4306	X2CrNi19-11	2352	SUS 304L
304H	S30409	304S51	-	1.4948	X6CrNi18-11	-	-
These comparisons are approximate only. The list is intended as a comparison of functionally similar materials not as a schedule of contractual equivalents. If exact equivalents are needed original specifications must be consulted.							

Possible Alternative Grades

Possible alternative grades to grade 304 stainless steels are given in table 5.

Table 5. Possible alternative grades to 304 grade stainless steel

Grade	Why it might be chosen instead of 304
301L	A higher work hardening rate grade is required for certain roll formed or stretch formed components.
302HQ	Lower work hardening rate is needed for cold forging of screws, bolts and rivets.
303	Higher machinability needed, and the lower corrosion resistance, formability and weldability are acceptable.
316	Higher resistance to pitting and crevice corrosion is required, in chloride environments
321	Better resistance to temperatures of around 600-900°C is needed...321 has higher hot strength.
3CR12	A lower cost is required, and the reduced corrosion resistance and resulting discolouration are acceptable.
430	A lower cost is required, and the reduced corrosion resistance and fabrication characteristics are acceptable.

Corrosion Resistance

Excellent in a wide range of atmospheric environments and many corrosive media. Subject to pitting and crevice corrosion in warm chloride environments, and to stress corrosion cracking above about 60°C. Considered resistant to potable water with up to about 200mg/L chlorides at ambient temperatures, reducing to about 150mg/L at 60°C.

Heat Resistance

Good oxidation resistance in intermittent service to 870°C and in continuous service to 925°C. Continuous use of 304 in the 425-860°C range is not recommended if subsequent aqueous corrosion resistance is important. Grade 304L is more resistant to carbide precipitation and can be heated into the above temperature range.

Grade 304H has higher strength at elevated temperatures so is often used for structural and pressure-containing applications at temperatures above about 500°C and up to about 800°C. 304H will become sensitised in the temperature range of 425-860°C; this is not a problem for high temperature applications, but will result in reduced aqueous corrosion resistance.

Heat Treatment

Solution Treatment (Annealing) - Heat to 1010-1120°C and cool rapidly. These grades cannot be hardened by thermal treatment.

Welding

Excellent weldability by all standard fusion methods, both with and without filler metals. AS 1554.6 pre-qualifies welding of 304 with Grade 308 and 304L with 308L rods or electrodes (and with their high silicon equivalents). Heavy welded sections in Grade 304 may require post-weld annealing for maximum corrosion resistance. This is not required for Grade 304L. Grade 321 may also be used as an alternative to 304 if heavy section welding is required and post-weld heat treatment is not possible.

Machining

A "Ugima" improved machinability version of grade 304 is available in bar products. "Ugima" machines significantly better than standard 304 or 304L, giving higher machining rates and lower tool wear in many operations.

Dual Certification

It is common for 304 and 304L to be stocked in "Dual Certified" form, particularly in plate and pipe. These items have chemical and mechanical properties complying with both 304 and 304L specifications. Such dual certified product does not meet 304H specifications and may be unacceptable for high temperature applications

Applications

- Food processing equipment, particularly in beer brewing, milk processing & wine making.
- Kitchen benches, sinks, troughs, equipment and appliances
- Architectural panelling, railings & trim
- Chemical containers, including for transport
- Heat Exchangers
- Woven or welded screens for mining, quarrying & water filtration
- Threaded fasteners
- Springs

Source: Atlas Steels Australia

Material Data Sheet: Stainless Steel 316 and 316L

Chemical Formula

Fe, <0.03% C, 16-18.5% Cr, 10-14% Ni, 2-3% Mo, <2% Mn, <1% Si, <0.045% P, <0.03% S

Background

Grade 316 is the standard molybdenum-bearing grade, second in importance to 304 amongst the austenitic stainless steels. The molybdenum gives 316 better overall corrosion resistant properties than Grade 304, particularly higher resistance to pitting and crevice corrosion in chloride environments. It has excellent forming and welding characteristics. It is readily brake or roll formed into a variety of parts for applications in the industrial, architectural, and transportation fields. Grade 316 also has outstanding welding characteristics. Post-weld annealing is not required when welding thin sections.

Grade 316L, the low carbon version of 316 and is immune from sensitisation (grain boundary carbide precipitation). Thus it is extensively used in heavy gauge welded components (over about 6mm). Grade 316H, with its higher carbon content has application at elevated temperatures, as does stabilised grade 316Ti.

The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures.

Key Properties

These properties are specified for flat rolled product (plate, sheet and coil) in ASTM A240/A240M. Similar but not necessarily identical properties are specified for other products such as pipe and bar in their respective specifications.

Composition

Typical compositional ranges for grade 316 stainless steels are given in table 1.

Table 1. Composition ranges for 316 grade of stainless steels.

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	N
316	Min	-	-	-	0	-	16.0	2.00	10.0	-
	Max	0.08	2.0	0.75	0.045	0.03	18.0	3.00	14.0	0.10
316L	Min	-	-	-	-	-	16.0	2.00	10.0	-
	Max	0.03	2.0	0.75	0.045	0.03	18.0	3.00	14.0	0.10
316H	Min	0.04	0.04	0	-	-	16.0	2.00	10.0	-
	max	0.10	0.10	0.75	0.045	0.03	18.0	3.00	14.0	-

Mechanical Properties

Typical mechanical properties for grade 316 stainless steels are given in table 2.

Table 2. Mechanical properties of 316 grade stainless steels.

Grade	Tensile Str (MPa) min	Yield Str 0.2% Proof (MPa) min	Elong (% in 50mm) min	Hardness	
				Rockwell B (HR B) max	Brinell (HB) max
316	515	205	40	95	217
316L	485	170	40	95	217
316H	515	205	40	95	217

Note: 316H also has a requirement for a grain size of ASTM no. 7 or coarser.

Physical Properties

Typical physical properties for annealed grade 316 stainless steels are given in table 3.

Table 3. Typical physical properties for 316 grade stainless steels.

Grade	Density (kg/m ³)	Elastic Modulus (GPa)	Mean Co-eff of Thermal Expansion (µm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0- 100°C (J/kg.K)	Elec Resistivity (nΩ.m)
			0- 100°C	0- 315°C	0- 538°C	At 100°C	At 500°C		
316/L/H	8000	193	15.9	16.2	17.5	16.3	21.5	500	740

Grade Specification Comparison

Approximate grade comparisons for 316 stainless steels are given in table 4.

Table 4. Grade specifications for 316 grade stainless steels.

Grade	UNS No	Old British		Euronorm		Swedish SS	Japanese JIS
		BS	En	No	Name		
316	S31600	316S31	58H, 58J	1.4401	X5CrNiMo17-12-2	2347	SUS 316
316L	S31603	316S11	-	1.4404	X2CrNiMo17-12-2	2348	SUS 316L
316H	S31609	316S51	-	-	-	-	-

Note: These comparisons are approximate only. The list is intended as a comparison of functionally similar materials not as a schedule of contractual equivalents. If exact equivalents are needed original specifications must be consulted.

Possible Alternative Grades

Possible alternative grades to grade 304 stainless steels are given in table 5.

Table 5. Possible alternative grades to 316 stainless steel.

Grade	Why it might be chosen instead of 316?
316Ti	Better resistance to temperatures of around 600-900°C is needed.
316N	Higher strength than standard 316.
317L	Higher resistance to chlorides than 316L, but with similar resistance to stress corrosion cracking.
904L	Much higher resistance to chlorides at elevated temperatures, with good formability
2205	Much higher resistance to chlorides at elevated temperatures, and higher strength than 316

Corrosion Resistance

Excellent in a range of atmospheric environments and many corrosive media - generally more resistant than 304. Subject to pitting and crevice corrosion in warm chloride environments, and to stress corrosion cracking above about 60 °C. Considered resistant to potable water with up to about 1000mg/L chlorides at ambient temperatures, reducing to about 500mg/L at 60 °C.

316 is usually regarded as the standard “marine grade stainless steel”, but it is not resistant to warm sea water. In many marine environments 316 does exhibit surface corrosion, usually visible as brown staining. This is particularly associated with crevices and rough surface finish.

Heat Resistance

Good oxidation resistance in intermittent service to 870 °C and in continuous service to 925 °C. Continuous use of 316 in the 425-860 °C range is not recommended if subsequent aqueous corrosion resistance is important. Grade 316L is more resistant to carbide precipitation and can be used in the above temperature range. Grade 316H has higher strength at elevated temperatures and is sometimes used for structural and pressure-containing applications at temperatures above about 500 °C.

Heat Treatment

Solution Treatment (Annealing) - Heat to 1010-1120 °C and cool rapidly. These grades cannot be hardened by thermal treatment.

Welding

Excellent weldability by all standard fusion methods, both with and without filler metals. AS 1554.6 pre-qualifies welding of 316 with Grade 316 and 316L with Grade 316L rods or electrodes (or their high silicon equivalents). Heavy welded sections in Grade 316 require post-weld annealing for maximum corrosion resistance. This is not required for 316L. Grade 316Ti may also be used as an alternative to 316 for heavy section welding.

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Machining

A “Ugima” improved machinability version of grade 316 is available in round and hollow bar products. This machines significantly better than standard 316 or 316L, giving higher machining rates and lower tool wear in many operations.

Dual Certification

It is common for 316 and 316L to be stocked in "Dual Certified" form - mainly in plate and pipe. These items have chemical and mechanical properties complying with both 316 and 316L specifications. Such dual certified product does not meet 316H specification and may be unacceptable for high temperature applications.

Applications

- Food preparation equipment particularly in chloride environments.
- Laboratory benches & equipment.
- Coastal architectural panelling, railings & trim.
- Boat fittings.
- Chemical containers, including for transport.
- Heat Exchangers.
- Woven or welded screens for mining, quarrying & water filtration.
- Threaded fasteners.
- Springs.

Source: Atlas Steels Australia