FIELD INSPECTION PRIOR TO COMMISSIONING OF MECHANICAL EQUIPMENT

DEP 61.10.08.11-Gen.

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DESIGN AND ENGINEERING PRACTICE

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The information set forth in these publications is provided to Shell companies for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual Operating Units to adapt the information set forth in DEPs to their own environment and requirements.

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Full document details: SHELL 61.10.08.11 0

TABLE OF CONTENTS

1. **INTRODUCTION** 5
1.1 SCOPE 5
1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS 5
1.3 DEFINITIONS 5
1.4 CROSS REFERENCES 6
1.5 SUMMARY OF CHANGES SINCE LAST REVISION 6

2. **INSPECTION** 7
2.1 GENERAL 7
2.2 ROGUE MATERIALS 7
2.3 DESIGN MODIFICATIONS 7

3. **MECHANICAL EQUIPMENT, GENERAL** 8

4. **VESSELS, COLUMNS, REACTORS AND THEIR INTERNALS** 9

5. **FURNACES** 10

6. **BOILERS** 12

7. **DESUPERHEATERS - STEAM TEMPERATURE CONTROL EQUIPMENT** 13

8. **SHELL-AND-TUBE HEAT EXCHANGERS** 14

9. **AIR-COOLED HEAT EXCHANGERS** 15

10. **GRAPHITE EQUIPMENT** 16

11. **ATMOSPHERIC STORAGE TANKS** 17

12. **ATMOSPHERIC TANKS FOR SOLIDS AND SILOS** 18

13. **PIPING** 19

14. **VALVES** 21

15. **SAFETY/RELIEF VALVES** 22

16. **RUBBER AND GRE/GRP-LINED EQUIPMENT** 24

17. **ROTATING EQUIPMENT** 25

18. **CENTRIFUGAL COMPRESSORS** 27

19. **RECIPROCATING COMPRESSORS/VACUUM PUMPS** 31

20. **ROTARY TYPE COMPRESSORS** 34

21. **BLOWERS/FANS** 36

22. **CENTRIFUGAL PUMPS** 37

23. **RECIPROCATING PUMPS** 39

24. **ROTARY POSITIVE-DISPLACEMENT PUMPS** 41

25. **MIXERS** 42

26. **ROTARY FILTERS** 45

27. **ROTATING DISC CONTACTORS** 47

28. **STEAM TURBINES** 48

29. **GAS TURBINES** 50

30. **DIESEL ENGINES** 52

31. **ROTARY STOP VALVES** 53

32. **EXTRUDERS** 54

33. **REFERENCES** 55

Documents
Document Sharing Hub

Full document details: SHELL 61.10.08.11 0

34 **BIBLIOGRAPHY** 56

APPENDICES

APPENDIX 1 RULES FOR EXPANDING FURNACE TUBES INTO RETURN FITTINGS ...57

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for field inspection prior to the commissioning of mechanical equipment (e.g. during new construction projects and minor projects, and existing equipment following maintenance or plant modifications).

The information given in this DEP has been arranged according to the type of equipment, such as columns, furnaces, compressors, pumps etc., and a separate section is dedicated to pressure testing procedures.

Excluded from the scope of this DEP is the inspection of the instrumentation associated with the mechanical equipment (for which DEP 62.10.08.11-Gen. shall apply).

Inspection of equipment can be divided into three main stages, only the **second** of which is within the scope of this DEP:

1) Manufacturing, which should be covered by the appropriate specifications, standards and codes laid down in the equipment purchase order.
2) Erection and pre-commissioning
3) Operational maintenance, which should be covered by local procedures at the operating site.

This DEP is a revision of the DEP with the same number dated March 2007. The only change in this revision is to remove content that has been incorporated into DEP 74.00.10.10-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This DEP is intended for use in oil refineries, chemical plants, gas plants, supply/marketing installations and, where applicable, in exploration and production.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

For the purposes of this DEP the following definitions shall apply:

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, installation, and commissioning or management of a project or operation of a facility. The Principal may sometimes undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for the Principal.

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The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (34).

1.5 SUMMARY OF CHANGES SINCE LAST REVISION

The only change in this revision is to remove content that has been incorporated into DEP 74.00.10.10-Gen.

Section	Change
3	Moved all of section 3 to a new DEP 74.00.10.10-Gen. Substantial revisions to pneumatic testing based on GS.09.52106
Appendix 1	Deleted and moved to DEP 74.00.10.10-Gen

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2. INSPECTION

2.1 GENERAL

Handover procedures shall be agreed between the Principal and the Contractor before precommissioning commences, and shall include the respective responsibilities of the Contractor, the Manufacturer and the Principal.

Early inspection of individual items will allow any non-compliances to be identified at an early stage, thus avoiding subsequent delays in construction progress. Furthermore, special attention to precommissioning inspection will contribute to equipment reliability when the equipment is brought on stream.

As it will not normally be possible to complete all checks on any one item at the same time, checklists should be used to ensure that essential points are not overlooked. Systematic performance of the handover inspections will facilitate the collection of accurate 'as-built' information and baseline measurements essential for completion of the Equipment Record Cards, see DEP 70.10.01.10-Gen.

The objective of inspection during construction or maintenance is to ensure that:

1. the equipment has been supplied in accordance with the purchase order;
2. the equipment has been installed correctly;
3. all required documentation has been completed.

A piece of equipment or part of an installation which is meant to operate with other equipment shall be inspected and tested in conjunction with the latter to ensure proper operation of the complete assembly, for example, a compressor together with its drive, auxiliary gear and piping system.

A record of all manufacturing data books, shop inspection reports, and the Manufacturer's inspection and test reports should be kept in the equipment file. This information shall be recorded on the appropriate Equipment Record Card, which shall be completed before commissioning. All pressure testing, when performed by a Contractor, shall be witnessed by the Principal and shall be recorded on the appropriate Equipment Record Card.

2.2 ROGUE MATERIALS

Rogue materials are equipment or piping components that are accidentally installed in a specific alloy (or special carbon steel) system, but do not meet the materials selection criteria for that system; this includes welding consumables.

In order to control the risk of installing rogue materials, DEP 31.10.00.10-Gen. shall apply.

2.3 DESIGN MODIFICATIONS

Design modifications during the manufacturing period may not be incorporated in the plant equipment after the final inspection in the shop. An up to date record shall be kept of all design modifications and associated specifications and drawings. The plant equipment shall be examined on arrival at site for compliance with purchase order requirements and any non-conformity reported and recorded. If the plant equipment requires modification on site it is essential that full and explicit information shall be made available, together with the certified materials required to perform the modifications. The modifications shall be performed in such a manner that the Manufacturer's guarantees are not invalidated.

Plant equipment which has been modified on site shall be subject to the same inspection requirements as for the original equipment.

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3. MECHANICAL EQUIPMENT, GENERAL

The following points are generally applicable to mechanical equipment. Points specific to particular types of equipment are included in the subsequent sections.

1. Check that all packing materials and protective devices used during transport and handling have been removed from the equipment, such as shock-absorbent materials from machined faces, blanking plates from orifices, blocking of shafts or rolling bearings and restraining devices from instruments, safety devices and protective equipment.
2. Check whether special (maintenance) tools and instruction manuals have been supplied.
3. Check that the nameplate is properly attached to the equipment in accordance with the specification. Compare the nameplate rating with the Equipment Record Card and note any variations.
4. Check the foundation bolts to make sure that they are straight and vertical and securely tightened. Shims should be located on either side of each foundation bolt and made in one piece. Layers of thin plates shall not be used.
5. Check whether the specified grouting is used and properly applied to baseplate and support.
6. Check that the insulation and fireproofing have been applied in accordance with the specification and that precautions have been taken to prevent the ingress of water.
7. Check and inspect any alterations made during plant construction and erection for compliance with the design specification, and record any deviations.
8. Check that specified materials have been used, see (2.2), and that welding, heat treatment, stress relieving and non-destructive testing have been carried out properly and fully documented.
9. Check wall thickness of shells, heat exchanger and furnace tubes, and nozzles and compare them with those stated on the Equipment Record Cards. Correct and complete these cards as necessary.
10. Check that the nozzle facings, flanges, flange finish, gaskets and stud bolts are in accordance with specified requirements and the alignment of flanges on process connections is correct.
11. Check the equipment for internal cleanliness before final sealing.
12. Check that the applied surface protection system complies with specified requirements.
13. Check that earth bosses are connected and in electrical contact with the shell.
14. Check that ladders, stairways, platforms and walkways are correctly installed, with handrails and flooring properly secured. Check operating platforms for alternative escape routes, which shall be freely accessible and clearly indicated.
15. Especially with vacuum equipment, if out-of-roundness, bulges or dents are suspected as a result of transport, handling, field welding or other cause, check the equipment and report any such defects. Procedures for rectification of any damage shall be agreed between the Principal and the Contractor.
16. Field welds shall be non-destructively tested where so specified, and the results recorded.
17. If a hydrostatic test is required in accordance with the design code and has not been carried out at the Manufacturer's works, such a test shall be performed locally. Field-erected equipment shall be hydrostatically tested according to Section (3). Particular attention shall be paid to those parts of equipment which have been modified during construction and erection.
18. A general inspection is required to check personnel hazards (e.g. tripping and headroom) associated with the accessibility of operating equipment. Hazards shall be removed or permanently marked and additional access provided as needed.

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4. VESSELS, COLUMNS, REACTORS AND THEIR INTERNALS

1. Check and inspect equipment internals for correct tray levels, weir heights, downcomer clearances, seal pans, draw-off trays, position of spiders, demisters and correct fastening, packing and bolts.
2. Check beam fastening and ensure one end is free to move.
3. Check the presence of drain holes where required and the hole configuration of liquid inlet devices in relation to the trays below.
4. Check and inspect the welds of stiffening rings, especially for vacuum equipment.
5. Check and inspect the strip lining, if applicable, especially at nozzle locations.
6. Check and inspect the lining of the cylindrical parts of manholes and nozzles, and the flange surface lining, if fitted.
7. Check that test holes in reinforcement plates are open.
8. Check that dewatering holes are located in appropriate positions.
9. Check the adjacent (steel) structure for interference with nozzles due to expansion/ contraction.
10. Check the verticality of tall equipment and the correct slope, if any, of horizontal equipment.
11. Test for leaks from the draw-off trays. An allowable leakage rate may be stated in the specification.
12. Before final boxing-up, a check on proper installation of internals, correct flange finishes and cleanliness shall be carried out jointly by operational and technical staff.

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5. FURNACES

1. Check the proper position and support of radiant and convection bank tubes. Remove any temporary bracing installed for transportation.
2. Check that the furnace tubes are straight and that there is proper clearance between the tubes; if not, adjust the roof tube supports by installing or removing shims.
3. Check whether tubes have been correctly expanded into fittings, see Appendix 2. Take readings of original expansion and enter these into the records.
4. Check that the return fitting plugs are properly bolted.
5. Check the fuel supply system, both oil and gas for leakage.
6. Check expansion joints for free movement (when hot)
7. Check the furnace structure and plating for correct bolting/welding, construction and painting of plates and beams; check roof for rain water draining facilities.
8. Check the dampers for correct operation. Ensure that the position marker on the outside coincides with the real position of the damper inside. Ensure that dampers will not close under the effect of gravity.
9. Check expansion pieces in ducting for tightness and adequate support near the expansion pieces.
10. Check provisions for installation and removal of spade-type blinds in flue gas ducting.
11. Check the burner installation, the correct position and shape of burner throats, the correct position of fuel guns in the throats, adjustability of air registers, fuel guns, the correct position and size of peepholes and observation windows. Record the result of the burner position measurement and issue a 'burner protocol' to be filled in by the inspection department.
12. Ensure that burner throats and ignition burner are visible from observation windows. Ensure that observation windows are not obstructed by furnace tubes.
13. Inspect the heater access doors. They should move freely and at the angle specified and should not be obstructed.
14. Inspect and test the steam to the furnace, i.e. snuffing steam to fire box and header boxes and steam for soot blowing and burners.
15. Inspect and test the soot blower equipment for correct working within the full range of operation.
16. Check sootblower system and in particular:
    - expansion;
    - purge facilities;
    - self-draining of steam supply piping system;
    - tightness of valves.
17. Test the concrete lining of the ducting for voids by tapping with a very light hammer. Inspect the lining for cracks wider than 1.5 mm. These cracks shall be cut out in such a way that a dovetail is obtained for repairs. For further checks on refractory, anchors, etc., see DEP 64.24.32.30-Gen.
18. Carry out a tightness test on air preheaters. Cleaning devices of fixed-type preheaters should be carefully checked. Packing between flanges shall be checked for tightness.
19. Apply a smoke-bomb test as a final check on the tightness of the firebox, ducting, dampers, air preheater etc. During this test the flue gas side shall be kept under pressure with the forced-draught fan.

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20. Hydrostatically test the furnace coils in accordance with the design data sheets. The test pressure shall be maintained for approximately half an hour plus the time required for checking on leaks (see Section 3).

21. After a furnace with horse-shoe type fittings has been closed following a routine cleaning or inspection shutdown, a tightness test shall be carried out to check that the horse shoe fittings do not leak. This test may be conducted with medium pressure steam, provided that the pressure and temperature do not exceed the furnace design conditions.

    If tubes or fittings have been repaired, a hydraulic test is required. The set pressure for this strength test shall be established by the plant inspector in accordance with local rules.

    Normally, the test pressure amounts to 1.5 times the design pressure multiplied by a factor S/S' where S and S' represent the allowable material stress values at ambient temperature and design temperature respectively.

22. Check proper installation of skin thermocouples (if applicable); see Standard drawing S 24.615.

23. Check operation of observation windows and the functioning of the air purge to the windows on the radiant cell.

24. Check that the locking pin of any spring hanger support is removed and the pointer within the operation range. Note the position in the cold, and later in the hot, condition.

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6. BOILERS

1. Check the boiler structure and plating for correct bolting/welding, construction/conservation plates, beams and painting.
2. Check that the air and flue gas ducts are adequately supported and that sufficient allowance has been made for expansion.
3. Check the fuel oil and gas supply system for leakage.
4. Check that the internals of the steam drum are in the correct position, properly fastened and free of debris. Check the downcomer and riser tubes, if possible.
5. Check the air preheater, if any.
6. Check that the intermittent blowdown lines are adequately supported and clamped. Make sure that the line size is not smaller than the blow-down connection.
7. Check that the blowdown valves are fail to close and check that continuous blowdown lines have position indicators (from 0 – 100 % with intervals of 10 %).
8. Check whether cleaning and boiling-out procedures have been carried out in accordance with the method described in DEP 70.10.80.11-Gen.
9. Check that statutory requirements have been satisfied.
10. Check the proper position of observation doors. Ensure that the burner throats, burner tips, side wall tubes, rear end tubes and superheater tubes are clearly visible.
11. Inspect the burner installation, the correct position and shape of burner throats, the correct position of the fuel guns in the throat, the adjustability of air registers, fuel guns, if applicable and the cleanliness of the fuel gun nozzles. Record the results of the burner position measurements.
12. Inspect and test the soot blower equipment for correct working within the full range of operations. Pay attention to purge facilities and steam shut-off valves.
13. Pressure test the boiler in accordance with the code or regulation under which it is designed. Boiler feed water shall be used as a testing medium (see Section 3).
14. Apply a smoke-bomb test as a final check on the tightness of the firebox, ducting, dampers, etc. During this test the flue gas side is kept under pressure with the forced-draught fan.
15. After starting up the boiler, the set pressure, maximum relief and the reseating pressure of the safety valves shall be checked at working temperature and adjusted if necessary.

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7. DESUPERHEATERS - STEAM TEMPERATURE CONTROL EQUIPMENT

1. Check that the direction of injection is correct.
2. Check the size of the injection nozzle and venturi.
3. Check that the bolts are in accordance with specified requirements.
4. Check that the forces and movements on flange connections are within acceptable limits and the equipment is adequately supported.
5. Check whether associated valves, instrumentation, and straight lengths of piping upstream and downstream of the injector are in accordance with the specification.
6. Check for proper installation of the low-alloy carbon steel inner tube, if fitted.

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8. SHELL-AND-TUBE HEAT EXCHANGERS

1. Check that the correct material has been used for drain/vent plugs.
2. Check whether anodes/sacrificial plates have been installed where specified.
3. Check that test holes in reinforcement plates are open and that dewatering holes are located in appropriate positions.
4. Check that threaded holes for pulling eyes in contact with the fluid are plugged off with dummy bolts.
5. Check that impingement protection, if provided, is properly installed.
6. Check that the extended bolt ends for bolt tensioning (external as well as internal) are properly protected.
7. Check that the test flange or test ring is present and properly stored.
8. Check the verticality of vertical heat exchangers and correct slope, if any, of horizontal heat exchangers.
9. New heat exchangers which have been tested at the Manufacturer's works in accordance with the design test pressures need not be retested after installation, unless required by local regulations. It is good practice, however, to test the tightness of the floating head and channel flanges. Pneumatic testing at a pressure of 1 bar (ga) is normally sufficient.
10. Whenever a shell cover, channel or floating head cover has been removed for cleaning or repair purposes, the heat exchanger shall be subject to a hydrostatic pressure test not exceeding 110 % of the design pressure.
11. Re-tubed replacement bundles shall be subjected to a full pressure test in situ to prove the tightness of the tube-to-tubesheet connections.
12. In cases where the heat exchanger design is based on differential pressure, care should be taken not to overload the tubesheets. Special care shall be taken if bellows are installed.
13. Heat exchangers provided with sheet gaskets which have been idle for more than three months after the date of hydrostatic testing at the Manufacturer's works may be opened on a spot-check basis to check for deterioration of the gaskets.

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9. AIR-COOLED HEAT EXCHANGERS

If fans are installed well in advance of being commissioned, consideration should be given to the manual rotating of motors and fans at regular intervals to prevent Brinelling of bearings and pre-setting of V-belts.

1. Check the clearance between blade tips and fan ring and check for equal and proper pitch angle setting of all fan blades.
2. Check whether fins of the cooler tubes have been damaged during transport or handling. Damaged fins may be straightened if practicable, otherwise damaged tubes shall be replaced.
3. Check that the correct material has been used for drain/vent plugs.
4. Check the sliding supports of the header box for free and unobstructed moving.
5. Check the proper operation of the louvre adjustment mechanism, if fitted.
6. Bearings of fans and drives shall be inspected for cleanliness and proper lubrication.
7. Any lengths of grease tubing installed to facilitate re-greasing of out-of-reach overhead bearings shall be disconnected and pumped through with fresh grease to clean and prime the tubing before it is reconnected to bearings. After this the use of automatic lubricators shall be considered.
8. The correct fan rotation and blade setting shall be checked.
9. Sections of heat exchangers of the air-cooled type are normally tested at the Manufacturer's works. After assembly the sections shall be tested together with the associated piping in accordance with the relevant codes.
10. It is essential to remove the test water by air blowing and drying, see (3).
11. If the fan blade pitch is automatically adjustable, check:
    - That the motor capacity is sufficient over the full pitch range;
    - The correct positioning of fan blades in case of air failure.
12. A general check of the construction should include:
    - The sealing between cooler bundles;
    - The correct sloping of the horizontal parts of the air plenum and tube bundles;
    - Alignment of belt pulleys;
    - Rigidity of fan and belt guards;
    - Proper tension of belt drives;
    - Tube vibration check at maximum airflow;
    - Guards protecting personnel from hot surfaces;
    - Proper alignment of process piping to headers to ensure no excessive nozzle loading;
    - Full priming of grease lines between grease nipple and bearing house;
    - Tightness of fan blade securing bolts;
    - Vibration of fan and motor as a baseline for further degradation of bearings.
13. New heat exchangers which have been tested at the Manufacturer's works in accordance with the design test pressures need not be retested after installation, unless required by local regulations. It is good practice, however, to test the tightness of the bundle. Pneumatic testing at 1 bar (ga) is normally sufficient.

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10. GRAPHITE EQUIPMENT

1. Graphite equipment is brittle and soft and can easily be damaged.
   - Carefully avoid mechanical impact and direct contact with metallic edges.
   - Graphite blocks, while they are outside the metallic shell, should be kept on a wooden base covered with corrugated cardboard, rubber mat, or other equally shock-absorbent material. Graphite blocks should be separated from each other by a sheet of corrugated cardboard.
   - A comparatively small dent in the region of the gasket recesses can render a graphite block useless.
2. Check that the graphite equipment has been installed in such way that it is accessible from all directions, thus allowing connecting pipes to be easily attached.
3. Check that the gaskets between the process fluid orifices of the equipment and the connecting piping are resistant to the fluids and process conditions and are in accordance with specified requirements.
4. Check that fastening torques and pressures are limited to those required for fluid tightness. If tightness is not achieved within the allowable torques or pressures specified by the Manufacturer, dismantle and replace the gaskets.
5. Check that the graphite equipment is not used as a support for piping.
6. Check that the connecting piping does not exert any strain, stress or bending moment on the graphite equipment. Ensure that bellows are correctly installed.
7. Check the diameter of the connecting pipework is not less than the corresponding orifices of the graphite equipment.
8. Check that tie rods, where provided, are tensioned.
9. After the piping is connected, check that the position of the tie rod bolts is within the limits as indicated by the Manufacturer to ensure proper spring loads.
10. Carbon tube exchangers should not be changed from vertical to horizontal position and vice versa.

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11. ATMOSPHERIC STORAGE TANKS

Inspection shall be carried out in accordance with DEP 64.51.01.31-Gen.

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12. ATMOSPHERIC TANKS FOR SOLIDS AND SILOS

Inspection shall be carried out in accordance with DEP 64.51.01.31-Gen.

Also:

1. Check for possible flow restrictions resulting from unground welds, especially at outlets. Check that manhole flush plates are in position. Check for any impediment to the free passage of solids and for proper alignment of flanged connections.
2. Check the inner surfaces for cleanliness and removal of debris.
3. Due to the large variety of above-ground storage facilities, further inspections shall depend on individual circumstances and be subject to agreement by the Principal.

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