U.S. Department
of Transportation

Pipeline and Hazardous Materials Safety Administration

1200 New Jersey Avenue, SE
Washington, D.C. 20590

AUG 21 2008

Mr. Daniel G. Shelton
Vice President
HazMat Resources, Inc.
10104 Creedmoor Road
Raleigh, NC 27615

Ref. No. 08-0125

Dear Mr. Shelton:

This is in response to your May 3, 2008 letter requesting clarification of the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) applicable to registration and recordkeeping requirements pertaining to Department of Transportation (DOT) specification cargo tanks. Your questions are paraphrased and answered as follows:

Q1. Do the registration requirements specified in Part 107, Subpart F of the HMR apply to a company that performs a Wet Fluorescent Magnetic Particle Examination (WFMPE) on MC 330 and MC 331 cargo tanks?

A1. Yes. In accordance with § 107.502, no person may engage in the manufacture, assembly, certification, inspection or repair of a cargo tank or cargo tank motor vehicle manufactured under the terms of a DOT specification or a special permit unless the person is registered with the Department in accordance with the provisions of Subpart F. A person employed as an inspector or design certifying engineer is considered to be registered if the person's employer is registered.

Q2. Section V of the ASME Code requires a written report when a WFMPE is performed. Is a written report required as part of the pressure test when a WFMPE is performed, or is it allowable to indicate on the pressure test report required by § 180.417 that a WFMPE was completed?

A2. In accordance with Section V of the ASME Code, a written report is required when a WFMPE is performed. In addition, each person performing a test or inspection specified in § 180.407 must prepare a written report in accordance with the reporting and recordkeeping requirements specified in § 180.417.

Q3. Section V of the ASME Code requires specific qualification and training requirements and documentation for persons performing a WFMPE. Are these documents required to be maintained and produced in accordance with the requirements of Section V of the ASME Code?

A3. Yes.

Q4. What DOT regulations require the maintenance of the additional documentation referenced in Q3?

A4. As required in § 180.407(g)(3), the wet fluorescent magnetic particle inspection must be in accordance with Section V of the ASME Code and CGA Technical Bulletin TB-2.

Q5. CGA Technical Bulletin TB-2, Section 5.6 states: "Determine the proper documentation has been completed, including marking of the tank. Refer to 49 CFR 180.415 and 180.417." Is this documentation required by the ASME Code or the HMR?

A5. The HMR incorporate Section V of the ASME Code by reference. Thus, when a WFMPE is performed, the HMR require a written report in accordance with Section V. In addition, the requirements of test and marking requirements specified in § 180.415 and the reporting and record retention requirements specified in § 180.417 must also be met.

I hope this information is helpful.

Sincerely,

Susan Gorsky,
Acting Chief, Standards Development
Office of Hazardous Materials Standards

Foster
§107.502(b)
§180.417
Registration/Cargo Tanks
08-0125

HazMat Resources, Inc.

10104 Creedmoor Road
Raleigh, N.C. 27615

May 3, 2008

Mr. Edward Mazzullo
Office Director, Office of Hazardous Materials Standards
U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration
East Building, 2nd Floor
Mail Stop: E21-317
1200 New Jersey Ave., SE
Washington, DC 20590

Mr. Mazzullo,

Please accept this letter as our request for an interpretation of the registration requirements in 49 CFR 107.502(b) which states in part the following:

"(b) No person may engage in the manufacture, assembly, certification, inspection or repair of a cargo tank or cargo tank motor vehicle manufactured under the terms of a DOT specification under subchapter C of this chapter or a special permit issued under this part unless the person is registered with the Department in accordance with the provisions of this subpart...."

I have attached for your reference e-mail correspondence dated October 6, 2004 which states that a person performing a welded repair to the cargo tank wall must have a CT number. I am sorry that the question was not in the attached e-mail but the question that prompted this response was this:

"If a facility that is registered with the Department does not have an "R" stamp, can they sub-contract the welded repair to a company that has an "R" stamp but does not have a CT number"

I addition, I have attached for your reference interpretation 05-0071 dated April 27, 2005 which further supports the Departments' position and creates the appearance that, even though a CT number is only a registration requirement, this interpretation states very clearly that without a CT number you are not **AUTHORIZED** ***(emphasis added)*** to

perform any function where registration is required. So, in effect, a CT number is an authorization to perform any of the functions where registration is required. I have also provided for your reference materials incorporated by reference CGA P-26 (formerly TB-2 titled Guidelines for Inspection and Repair of MC 330 and MC 331 anhydrous ammonia cargo tanks) and Section V article 7 of the ASME code.

MC 330 and 331 cargo tank motor vehicles are generally required to undergo a pressure test at certain intervals. The requirements in 49 CFR 180.407(g)(3)state as follows:

"Each MC 330 and MC 331 cargo tank constructed of quenched and tempered steel in accordance with Part UHT in Section VIII of the ASME Code (IBR, see §171.7 of this subchapter), or constructed of other than quenched and tempered steel but without postweld heat treatment, used for the transportation of anhydrous ammonia or any other hazardous materials that may cause corrosion stress cracking, must be internally inspected by the wet fluorescent magnetic particle method immediately prior to and in conjunction with the performance of the pressure test prescribed in this section. Each MC 330 and MC 331 cargo tank constructed of quenched and tempered steel in accordance with Part UHT in Section VIII of the ASME Code and used for the transportation of liquefied petroleum gas must be internally inspected by the wet fluorescent magnetic particle method immediately prior to and in conjunction with the performance of the pressure test prescribed in this section. The wet fluorescent magnetic particle inspection must be in accordance with Section V of the ASME Code and CGA Technical Bulletin TB-2 (IBR, see §171.7 of this subchapter). This paragraph does not apply to cargo tanks that do not have manholes. (See §180.417(c) for reporting requirements.)

Question 1: Not all MC 330 and MC 331 cargo tanks required a Wet Fluorescent Magnetic Particle Examination (WFMPE) immediately prior to and in conjunction with a pressure test so it appears this WFMPE is an additional test that must be performed. Because this non destructive testing (NDE) is very technical in nature most facilities contract this service out to companies that specialize in NDE. Because this is a separate test, is the person who performs the WFMPE required to be registered with the Department and get a CT number.

The WFMPE must be performed in accordance with Section V of the ASME Code and CGA Technical Bulletin TB-2. The following questions refer to these documents:

Question 1: Section V of the ASME Code requires a written report. Is a written report required as part of the pressure test when a WFMPE is performed or can one simply say on the pressure test report required by 180.417 that a WFMPE was completed?

Question 2: Section V of the ASME Code requires specific qualification and training requirements and documentation for anyone performing a WFMPE. Are these documents required to be maintained and produced in accordance with the requirements of Section V of the ASME Code?

Question 3: Regarding the qualification and training documents reference in Question 2, what DOT regulations would require me to maintain these additional qualification documents over and above what is currently required in 49 CFR 172.704(d).

Question 4: CGA Technical Bulletin TB-2 Section 5.6 states as follows: "Determine the proper documentation has been completed, including marking of the tank. Refer to 49 CFR 180.415 and 180.417. What proper documentation is this bulletin referring to? Is it the documentation required by Section V of the ASME Code, the documentation required in 180.417(b), the documentation required in 180.417(c), none of the above, all of the above or some combination?

Thank you in advance for your reply.

Sincerely

Daniel G. Shelton
Vice President
HazMat Resources, Inc.

Attachments: Reply from Joe Solomey dated 10/06/2004
Letter to Determan Brownie, Inc. dated 04/27/2005 Ref – 05-0071
CGA Pamphlet 26
Section V of the ASME Code

From: Solomey, Joe <RSPA>
Sent: Wednesday, October 06, 2004 12:44 PM
To: Shelton, Danny

Danny sorry for the delayed reply. Repair is defined in 49 CFR Part § 180.403 as any welding on a cargo tank wall done to return a cargo tank or a cargo tank motor vehicle to its original design and construction specification, or to a condition prescribed for a later equivalent specification in effect at the time of the repair. The repair function is identified in 49 CFR Part § 107.502 as a function where registration is required. 49 CFR § 107.502(b) specifically states that no person may engage in the manufacture, assembly, certification, inspection or repair of a cargo tank or cargo tank motor vehicle manufactured under the terms of a DOT specification under subchapter C of this chapter or an exemption issued under this part unless the person is registered with the Department in accordance with the provisions of this subpart. The short version of this is if you are performing a function where registration is required, you need to be registered with the Department. There is no cost to the registration process and places no unnecessary burden on the public.

I hope this information is helpful.

Joe

Joseph Solomey
Research and Special Programs Administration Assistant Chief Counsel Hazardous Materials Safety and Emergency Transportation Law Division 400 7th. Street, S.W., Room 8417 Washington, D.C. 20590
(202) 366-0977 (Phone)
(202) 366-7041 (Fax)
joe.solomey@rspa.dot.gov <mailto:joe.solomey@rspa.dot.gov>

U.S. Department
of Transportation

**Pipeline and
Hazardous Materials Safety
Administration**

400 Seventh Street, S.W.
Washington, D.C. 20590

APR 27 2005

Mr. Dave Anderson
Determan Brownie, Inc.
1241 - 72nd Avenue Northeast
Minneapolis, MN 55432

Ref No.: 05-0071

Dear Mr. Anderson,

This is in response to your letter dated March 24, 2005, requesting clarification of the requirements contained in the Hazardous Materials Regulations (HMR; 49 CFR Parts 100-185) applicable to manufacturing and retesting a DOT Specification 406 cargo tank motor vehicle (CTMV). Specifically, you ask several questions regarding the testing requirements for a DOT Specification 406 CTMV. In addition, you indicate that the cargo tank does not meet the requirements prescribed in Part 178, Subpart J for the specification.

Your questions are paraphrased and answered as follows:

Q1. May a company that is not registered with the Department, in accordance with Part 107, Subpart F, manufacture a DOT Specification 406 CTMV?

A1. No. The definition of a manufacturer provided in § 178.320 states that a manufacturer must register with the Department in accordance with Part 107, Subpart F of the HMR. In addition, § 107.502(b) indicates that no person may manufacture a DOT specification cargo tank or CTMV unless that person is registered.

Q2. In accordance with § 180.417(a)(3), may the owner prepare a manufacturer's certificate based on specification markings that were placed on the cargo tank by a person who manufactured the CTMV, but was not registered with the Department?

A2. No. Section 180.417(a)(3) applies to DOT specification CTMVs manufactured before September 1, 1995. However, even if the CTMV was manufactured prior to September 1, 1995, you may not prepare a manufacturer's certificate based on information supplied by a person who was not authorized to manufacture the CTMV.

Q3. May the owner of the CTMV create the documents that are required to be maintained by § 178.345-15?

A3. No. The owner of the CTMV is not permitted to create the documents identified in § 178.345-15. The documents must be supplied to the owner by the manufacturer of the CTMV. This includes the certification documents that display the registration

number of the manufacturer, the Design Certifying Engineer, and the Registered Inspector. In addition, these documents must include a certificate signed by a responsible official of the manufacturer and a Design Certifying Engineer certifying that the CTMV meets the applicable specification.

Because the owner is unable to provide any of the required documents and because the person who manufactured the CTMV was not an authorized manufacturer, the cargo tank must be certified under the procedures applicable to newly constructed cargo tanks. In the situation described in your letter, you would be converting a non-specification CTMV into a DOT specification CTMV. To accomplish this, your company could become the manufacturer of the CTMV and issue the certificates identified in § 178.345-15. This would entail registration as a cargo tank manufacturer in accordance with Part 107, Subpart F and performance of all tests and inspections under Part 178, Subpart J, as applicable to the DOT Specification 406 CTMV described in your documented QC program used to obtain your ASME Code "U" stamp.

I hope this information is helpful. Please contact us if you require additional assistance.

Sincerely,

John A. Gale
Chief, Standards Development
Office of Hazardous Materials Standards

CGA P-26—1997 (Formerly TB-2)

GUIDELINES FOR INSPECTION AND REPAIR OF MC-330 AND MC-331 ANHYDROUS AMMONIA CARGO TANKS

Fifth Edition, 1997

COMPRESSED GAS ASSOCIATION, INC.
1725 Jefferson Davis Hwy., Suite 1004
Arlington, VA 22202
703-412-0900

PLEASE NOTE:

The information contained in this document was obtained from sources believed to be reliable and is based on technical information and experience currently available from members of the Compressed Gas Association, Inc. and others. However, the Association or their members, jointly or severally, make no guarantee of the results and assume no liability or responsibility in connection with the information or suggestions herein contained. Moreover, it should not be assumed that every acceptable commodity grade, test or safety procedure or method, precaution, equipment or device is contained within, or that abnormal or unusual circumstances may not warrant or suggest further requirements or additional procedure.

This document is subject to periodic review and users are cautioned to obtain the latest edition. Comments and suggestions are invited from all users for consideration by the Association in connection with such review; any such comments or suggestions will be fully reviewed by the Association after giving the party, upon request, a reasonable opportunity to be heard. (See proposed change sheet on last printed page of this document.)

This document should not be confused with federal, state, provincial or municipal specifications or regulations, insurance requirements or national safety codes. While the Association recommends reference to or use of this document by government agencies and others, this document is purely voluntary and not binding.

A catalog listing of all publications, audiovisual programs, safety and technical bulletins, and safety posters is available at no charge upon request from the Compressed Gas Association, Inc. Phone 703-412-0900, ext. 799. Fax 703-412-0128. E-mail CustomerService@cganet.com.

NOTE: Technical changes from the previous edition are underlined to easily identify them for the reader.

FIFTH EDITION: 1997
FOURTH EDITION: 1989
THIRD EDITION: 1980
SECOND EDITION: 1975

1725 JEFFERSON DAVIS HWY., SUITE 1004, ARLINGTON, VA. 22202
Printed in U.S.A.

Contents **Page**

1 Introduction

1.1 The U.S. Department of Transportation (DOT) Hazardous Materials Regulations in 49 CFR 180.407(g)(3) require that MC-330 and MC-331 anhydrous ammonia cargo tanks that are constructed of quenched and tempered steel or constructed of other than quenched and tempered steel but without post-weld heat treatment be internally inspected by the wet fluorescent magnetic particle method at certain prescribed intervals. Cracks and other defects found during the inspection shall be repaired in accordance with the requirements in 49 CFR Part 180, Subpart E, "Qualification and Maintenance of Cargo Tanks," if a cargo tank is to be returned to transportation service [1].[1]

1.2 In order to promote uniformity within the industry, the Compressed Gas Association has prepared these guidelines for use by personnel having responsibility for the inspection and repair of these cargo tanks.

2 Inspection

2.1 The wet fluorescent magnetic particle method shall be used, and the test procedure shall be in accordance with the applicable portions of Section V of the ASME Code [2]. The alternating current yoke method shall be used.

2.2 The surfaces to be inspected shall be cleaned to remove oil, loose scale, and rust. All of these materials shall be removed from surfaces with sufficient care to clean crevices and corners so that the test solution will flow freely. Failure to do this will result in erroneous indications or the masking of indications. Care should be exercised to magnetize each area in directions that would cross any crack regardless of the crack's orientation. Yokes should be positioned to effectively overlap magnetized areas. The speed of inspection should be slow enough to allow particle buildup at cracks. The continuous method of inspection should be used so that current and test solution are flowing while the inspection is being made with the black light. Visible light should be eliminated entirely or kept at a level that does not appreciably lessen the fluorescent image. Fluorescent materials should be mixed according to the recommendations of the manufacturer and should be agitated frequently during use. Black light output diminishes with use and should be checked periodically with a light meter according to the recommendations of the fluorescent material's manufacturer.

2.3 The wet fluorescent magnetic particle inspection shall include:

- all welds in or on the interior surface of the tank, and the adjacent base plate extending 2 inches (5 cm) from either side of such welds;
- the entire interior surface of tank heads; and
- all interior surfaces at least 2 inches (5 cm) in all directions from exterior welds that are visibly discernible on the interior of the tank.

In addition, the entire interior surface of the tank should be visually inspected, and any areas showing evidence of grinding or other repairs or disturbances of the plate surface should be inspected by the wet fluorescent magnetic particle method. If any cracks are found, the entire interior surface shall also be inspected.

3 Repair

3.1 All cracks and other defects, except porosity and slag inclusions in the weld deposit that are acceptable under the ASME Code, Section VIII Division I shall be removed or repaired [3]. The removal and repair procedures employed shall comply with those contained in the latest edition and addenda of the National Board Inspection Code [4]. Where specific procedures are not given, it is intended that, subject to the approval of the inspector, all repairs shall conform insofar as possible to the ASME Code most applicable to the best performance of the work planned [5]. The construction standard selected shall be the one considered by the inspector as the most compatible with the nature of the repair and the conditions of original construction. Before proceeding with any welded repairs, the repair facility should have a copy of the Manufacturer's Data Report, Form U1 or U1A.

[1] References in this document are shown by bracketed numbers and are listed in order of appearance in section 7, References.

3.2 Some minor cracks and other defects may be removed by grinding. In no case shall grinding be done that would reduce the wall thickness below that shown on the data plate minus 0.010 inch (0.254 mm). Grinding pressure should be light, and the material should not be overheated. Heavy grinding pressure will produce mechanical work hardening, and overheating will induce hard spots and high residual stresses. Material can be prevented from getting too hot by using a coolant or intermittently grinding and cooling. All ground areas must be properly contoured and feathered to eliminate stress raisers such as a sharp discontinuity in the surface.

3.3 Repairs by welding on the pressure vessel shall only be performed by a repair organization holding a valid National Board Certificate authorizing the use of the "R" stamp and registered in accordance with Title 49 CFR 107, Subpart F [1].

Authorization and acceptance of any repairs made shall be in accordance with the requirements of Paragraph RC-1000 of the National Board Inspection Code [4].

3.4 Welding on the pressure vessel, thermal heat treatment, materials employed for repairs, replacement of pressure parts, nondestructive examination, and pressure tests as required shall all conform to the requirements of Paragraphs RC-1000 and RC-2000 of the National Board Inspection Code [4].

3.5 Defect removal, replacement of major pressure parts, and the repair methods employed shall meet the applicable requirements of Paragraph RD-1000 of the National Board Inspection Code [4].

3.6 Cracks that are not removable in accordance with the ASME Code by surface grinding shall be removed by acceptable means until no further cracks are revealed by wet fluorescent magnetic particle inspection, and the area filled by welding in an approved manner. Preheat the area to between 100 °F to 200 °F (37.8 °C to 93.3 °C) to remove moisture and prevent too rapid cooling, which occurs on small welds. The straight-stringer-bead technique is suggested for weld metal deposition. This is considered a minor repair.

3.7 In some areas, cracks may be so numerous that repairing each crack would not be practical. In this case, a section may be removed and a new section installed using the same material procedures and fabrication techniques required by the ASME Code and 49 CFR 180, Subpart E [1].

3.8 After welding, the weld reinforcement should be ground in accordance with the ASME Code, and any undercuts found should either be feather ground or weld-repaired and ground. Precautions should be taken to avoid overheating and creating coarse surfaces from grinding. Groove weld repairs shall be radiographed wherever practical.

3.9 No post-weld heat treatment after minor repairs is required. Post-weld heat treatment is required after major repairs.

3.10 After welding repairs, the area shall be reinspected by the wet fluorescent magnetic particle method. The tank shall also be hydrostatically retested to a pressure at least twice the tank design pressure for quenched and tempered steels or 1 1/2 times the tank design pressure for other than quenched and tempered steels. The repaired area, including the exterior portion of the weld if it penetrates the entire thickness of the material, shall then be reinspected by the wet fluorescent magnetic particle method.

3.11 Documentation and marking of any pressure vessel repair made shall satisfy the applicable requirements of Paragraphs RC-2070 and RC-2060 of the National Board Inspection Code and requirements of the DOT [4]. See 5.6.

4 Preparations prior to cargo tank entry, inspection, and repair

The following suggestions are general in nature and are not intended to be all-inclusive or fully descriptive of a plan to provide for every consequence that may occur. Repair shop owners or managers are advised to develop specific procedures suited to their particular workplace requirements for the protection of employees, the general public, property, and the surrounding environment from liquid or gaseous hazardous materials, which may be corrosive, explosive, or otherwise harmful.

4.1 Repair shop owners or managers should comply with the requirements promulgated by the

DOT in 49 CFR 177.854(g), "Repairs and Maintenance of Vehicles Containing Certain Hazardous Materials;" 49 CFR 180.413, "Repair, Modification, Stretching, or Re-barreling of Cargo Tanks;" and 29 CFR 1910.146, "Permit-required Confined Spaces" [1, 1, 6]. State and local regulations may also apply and should be observed accordingly. At a minimum, no work should be performed on a cargo tank containing a hazardous material inside a shop building unless:

- the cargo tank and auxiliary piping have been determined to be free of leakage;
- means are provided to immediately remove the cargo tank from the building, if necessary, in an emergency; and
- all sources of spark, flame, or glowing heat within the building (including any heating system drawing air there) are extinguished, made inoperable, or rendered explosion-proof by suitable means if the hazardous material is flammable or can be ignited.

4.2 Identify any residual material in tank. Review the Material Safety Data Sheet (MSDS) to determine the chemical and physical properties, methods of handling, health hazards, personal protective requirements, and environmental protective requirements.

4.3 Transfer residual material from the tank and auxiliary piping to a suitable and approved storage container or to a properly engineered disposal system that is designed and operated in a manner consistent with all applicable requirements of local, state, and federal environmental and safety regulatory agencies.

4.4 Remove residual vapor from the tank and auxiliary piping by suitable means, which may include ventilating with air, inert gas, or displacing with water. The method selected shall be compatible with the residual vapor being removed and shall not result in off-site contamination or cause conditions that can lead to combustion, respiratory effects, or other harmful consequences.

4.5 Provide an adequate supply of fresh air to the tank interior.

4.6 Determine that a safe atmosphere exists within the tank before allowing personnel to enter. Oxygen, combustible gas, and air contaminant level readings shall be taken with suitable monitoring instruments properly operated and maintained in accordance with the manufacturer's instructions. In general, oxygen content should be greater than 19.5% and not more than 20.9%. Combustible gas levels should be less than 10% of the Lower Explosive Limit (LEL) for the material involved, and air contaminant levels should be held within limits that will permit compliance with the standards set by the Occupational Safety and Health Administration (OSHA) in 29 CFR 1910.1000, which governs employee exposure in the workplace [6]. Guidelines for threshold limit values for chemical substances in the work environment are given in the American Conference of Governmental Industrial Hygienist's publication, *TLVs: Threshold Limit Values for Chemical Substances in the Work Environment* [7]. State and local regulations may impose more stringent requirements than those indicated and should be reviewed.

5 Suggested inspection procedure

For the added guidance of those not experienced in the inspection of cargo tanks, the following steps are suggested:

5.1 Remove the manhole cover(s), valves, and fittings as required.

5.2 Check that the interior surface is clean and free from oil, loose rust or scale, and residue at the bottom. Clean as required with the following suggestions:

- oil: Steam or solvent clean. (Avoid flammable solvents.);
- rust and loose scale: Wire brush or sandblast; and
- residue: Scoop out and vacuum;

5.3 Visually inspect the interior with a floodlight, marking any areas showing evidence of weld repair of the parent metal, manufacturing clips, grinding, or other disturbance of the plate surface.

5.4 Mark interior areas corresponding to external structural pad attachments, which must be inspected in accordance with 2.3.

5.5 Inspect marked areas, interior of heads, and areas up to 2 inches (5 cm) from all interior welds using the wet fluorescent magnetic particle method.

5.5.1 Start on the head opposite the manhole; work toward the manhole.

5.5.2 Work from the bottom up.

5.5.3 Be equipped with a grinder to evaluate the findings.

5.5.4 Proceed with an inspection of the entire interior surface if cracks or defects requiring such inspection are discovered.

5.5.5 Mark and record the repaired areas.

5.6 Determine that the proper documentation has been completed, including marking of the tank. Refer to 49 CFR 180.415 and 180.417 [1].

6 Personnel health, safety, and training

The health and safety hazards at a repair shop will be specific to that particular facility. Thus, a complete list of precautions and recommendations addressing all possible hazards is beyond the scope of this publication. Risks associated with shop operation can be minimized through the implementation of appropriate engineering, administrative, and personal protective controls. These include the proper selection and application of facility design, shop equipment, personal protective equipment and clothing, safety precautions, and thorough employee training. Standards and guidelines for minimizing hazards to personnel in the workplace may be found in the OSHA Standards, 29 CFR 1910 [6]. Repair shop owners or managers should understand and comply with these regulations.

Some examples of safety procedures and programs to be implemented and vigorously enforced are:

- determining that the interior tank atmosphere is safe through use of air monitoring equipment such as combustible gas, oxygen, and air contaminant level indicators before allowing entry or permitting welding, grinding, cutting, cleaning, or other activities. Periodic air quality determinations during a work cycle may be appropriate;
- maintaining continuous and adequate fresh air flow into the tank interior for employee safety during the work cycle;
- requiring employees working in a confined space to use the "buddy" system. Provisions should be made to maintain constant visual and audible communication between the employees who should be trained in rescue and first aid procedures;
- avoiding excessive contact with cleaning and inspection fluids, and using protective creams;
- providing appropriate protective clothing for employee use such as chemical-resistant clothing, boots, gloves, goggles, and face shields;
- furnishing approved respiratory protective equipment for employee use as needed together with safety belts, safety lines, and ladders;
- grounding the tank, and using only lighting and electrical equipment that is either intrinsically safe or grounded; and
- providing employee training on a periodic basis in areas such as, but not limited to, first aid, safe job procedures, proper use of respiratory protective equipment, emergency contingency plans, and physical and chemical hazards associated with the work requirements.

7 References

[1] *Code of Federal Regulations*, Title 49 CFR Parts 100-180, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[2] *ASME Boiler and Pressure Vessel Code, Section V-Nondestructive Examination*, American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017.

[3] *ASME Boiler and Pressure Vessel Code, Section VIII (Division 1) - Unfired Pressure Vessels,*

American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017.

[4] *National Board Inspection Code – 1995 Edition*: NB-23, National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, Ohio, 43229.

[5] *ASME Boiler and Pressure Vessel Code, Section IX – Welding Qualifications*, American Society of Mechanical Engineers, 345 East 47th St., New York, NY 10017.

[6] *Code of Federal Regulations*, Title 29 Parts 1900 – 1910, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

[7] *TLVs: Threshold Limit Values for Chemical Substances in the Work Environment*, 1997, American Conference of Governmental Industrial Hygienists 1330 Kemper Meadow Dr., Cincinnati, OH 45240.

8 Additional source of information

Pocket Guide to Chemical Hazards, NIOSH/OSHA, DHEW (NIOSH) Publication No. 85-114, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

ARTICLE 7

Figures

Mandatory Appendices

A99
A00

ARTICLE 7
MAGNETIC PARTICLE EXAMINATION

T-710 SCOPE

When specified by the referencing Code Section, the magnetic particle examination techniques described in this Article shall be used. In general, this Article is in conformance with SE-709, Standard Guide for Magnetic Particle Examination. This document provides details to be considered in the procedures used.

When this Article is specified by a referencing Code Section, the magnetic particle method described in this Article shall be used together with Article 1, General Requirements. Definition of terms used in this Article are in Mandatory Appendix II.

T-720 GENERAL

The magnetic particle examination method may be applied to detect cracks and other discontinuities on or near the surfaces of ferromagnetic materials. The sensitivity is greatest for surface discontinuities and diminishes rapidly with increasing depth of subsurface discontinuities below the surface. Typical types of discontinuities that can be detected by this method are cracks, laps, seams, cold shuts, and laminations.

In principle, this method involves magnetizing an area to be examined, and applying ferromagnetic particles (the examinations medium) to the surface. The particles will form patterns on the surface where cracks and other discontinuities cause distortions in the normal magnetic field. These patterns are usually characteristic of the type of discontinuity that is detected.

Whichever technique is used to produce the magnetic flux in the part, maximum sensitivity will be to linear discontinuities oriented perpendicular to the lines of flux. For optimum effectiveness in detecting all types of discontinuities, each area should be examined at least twice, with the lines of flux during one examination approximately perpendicular to the lines of flux during the other.

T-730 EQUIPMENT A99

A suitable and appropriate means for producing the necessary magnetic flux in the part shall be employed, using one or more of the techniques listed in T-752 and described in T-770.

T-731 Examination Medium A99 A00

The finely divided ferromagnetic particles used for the examination shall meet the following requirements.

(a) Particle Types. The particles shall be treated to impart color (fluorescent pigments, nonfluorescent pigments, or both) in order to make them highly visible (contrasting) against the background of the surface being examined.

(b) Particles. Dry and wet particles, including wet particle suspension vehicles, and particle concentrations shall be in accordance with SE-709.

(c) Temperature Limitations. Particles shall be used within the temperature range limitations set by the manufacturer. Alternatively, particles may be used outside the manufacturer's recommendations providing the procedure is qualified in accordance with Article 1, T-150.

T-740 REQUIREMENTS

T-741 Surface Conditioning

T-741.1 Preparation A99

(a) Satisfactory results are usually obtained when the surfaces are in the as-welded, as-rolled, as-cast, or as-forged conditions. However, surface preparation by grinding or machining may be necessary where surface irregularities could mask indications due to discontinuities.

(b) Prior to magnetic particle examination, the surface to be examined and all adjacent areas within at least 1 in. shall be dry and free of all dirt, grease, lint,

scale, welding flux and spatter, oil, or other extraneous matter that could interfere with the examination.

(c) Cleaning may be accomplished using detergents, organic solvents, descaling solutions, paint removers, vapor degreasing, sand or grit blasting, or ultrasonic cleaning methods.

(d) If coatings are left on the part in the area being examined, it must be demonstrated that indications can be detected through the existing maximum coating thickness applied. When AC yoke technique is used, the demonstration must be in accordance with Mandatory Appendix I of this Article.

A99 **T-741.2 Surface Contrast Enhancement.** When coatings are applied temporarily to uncoated surfaces only in amounts sufficient to enhance particle contrast, it must be demonstrated that indications can be detected through the enhancement coating.

NOTE: Refer to T-150(a) for guidance for the demonstration required in T-741.1(d) and T-741.2.

A00 **T-750 PROCEDURE/TECHNIQUE**

Examination procedures shall be based on the following information:

(a) the materials, shapes, or sizes to be examined, and the extent of the examination;

(b) magnetization techniques to be used;

(c) equipment to be used for magnetization;

(d) surface preparation (finishing and cleaning);

(e) type of ferromagnetic particles to be used: manufacturer, color, wet or dry, etc.;

(f) magnetization currents (type and amperage);

(g) demagnetization;

(h) postexamination cleaning.

T-751 Method of Examination

Examination shall be done by the continuous method; that is, the magnetizing current remains on while the examination medium is being applied and while excess of the examination medium is being removed.

T-752 Techniques and Materials

The ferromagnetic particles used as an examination medium shall be either wet or dry, and may be either fluorescent or nonfluorescent.

One or more of the following five magnetization techniques shall be used:

(a) prod technique;

(b) longitudinal magnetization technique;

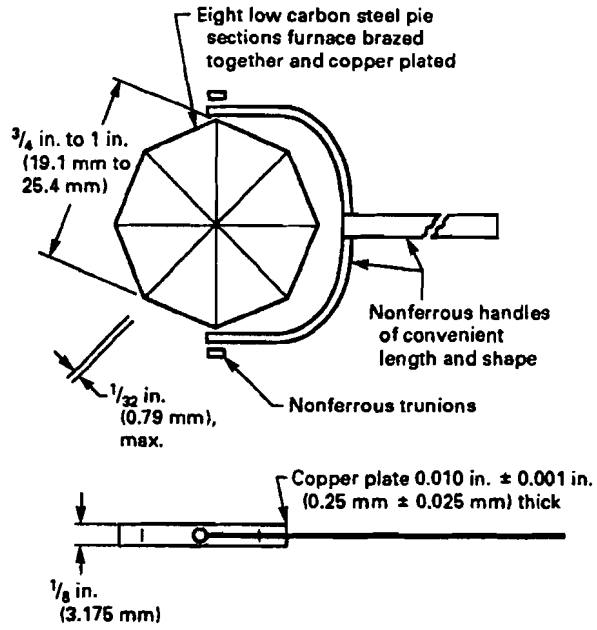


FIG. T-753.1.1 PIE-SHAPED MAGNETIC PARTICLE FIELD INDICATOR A99

(c) circular magnetization technique;

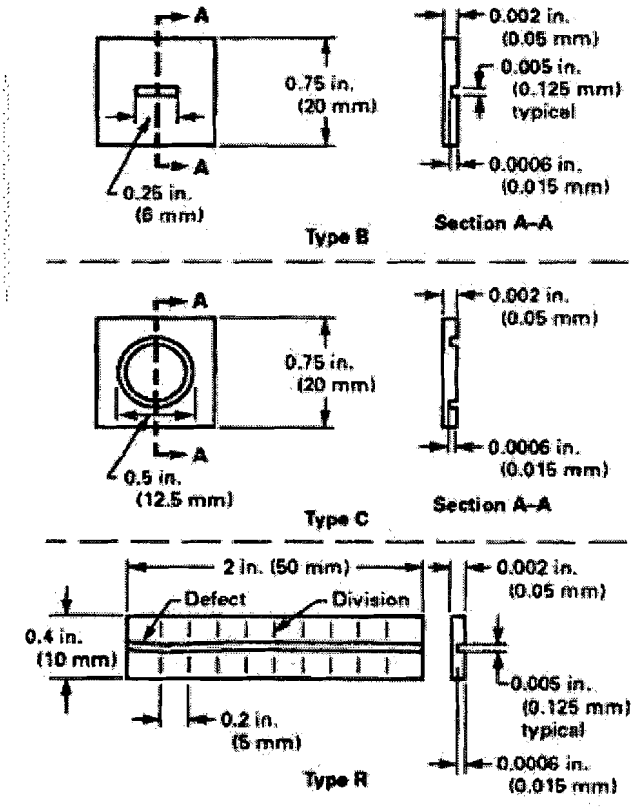
(d) yoke technique;

(e) multidirectional magnetization technique.

T-753 Magnetizing Field Adequacy and Direction A99

T-753.1 Magnetic Field Adequacy. The applied magnetic field shall have sufficient strength to produce satisfactory indications, but it shall not be so strong that it causes the masking of relevant indications by nonrelevant accumulations of magnetic particles. Factors that influence the required field strength include the size, shape, and material permeability of the part; the technique of magnetization; coatings; the method of particle application; and the type and location of discontinuities to be detected. When it is necessary to verify the adequacy of magnetic field strength. it shall be verified by using one or more of the following three methods.

T-753.1.1 Pie-Shaped Magnetic Particle Field Indicator. The indicator, shown in Fig. T-753.1.1, shall be positioned on the surface to be examined, such that the copper-plated side is away from the inspected



GENERAL NOTE:
Above are examples of artificial flaw shims used in magnetic particle inspection system verification (not drawn to scale). The shims are made of low carbon steel (1005 steel foil). The artificial flaw is etched or machined on one side of the foil to a depth of 30% of the foil thickness.

A99 **FIG. T-753.1.2 ARTIFICIAL FLAW SHIMS**

surface. A suitable field strength is indicated when a clearly defined line (or lines) of magnetic particles form(s) across the copper face of the indicator when the magnetic particles are applied simultaneously with the magnetizing force. When a clearly defined line of particles is not formed, the magnetizing technique shall be changed as needed. Pie-type indicators are best used with dry particle procedures.

T-753.1.2 Artificial Flaw Shims. The shim, shown in Fig. T-753.1.2, shall be attached to the surface to be examined, such that the artificial flaw side of the shim is toward the inspected surface. A suitable field strength is indicated when a clearly defined line (or lines) of magnetic particles, representing the 30% depth flaw, appear(s) on the shim face when magnetic particles are applied simultaneously with the magnetizing force. When a clearly defined line of particles is not formed, the magnetizing technique shall be changed as needed. Shim-type indicators are best used with wet particle procedures.

T-753.1.3 Hall-Effect Tangential-Field Probe. A gaussmeter and Hall-Effect tangential-field probe shall be used for measuring the peak value of a tangential field. The probe shall be positioned on the surface to be examined, such that the maximum field strength is determined. A suitable field strength is indicated when the measured field is within the range of 30 G to 60 G (2.4 kAm^{-1} to 4.8 kAm^{-1}) while the magnetizing force is being applied. See Article 7, Nonmandatory Appendix A.

T-753.2 Magnetic Field Direction. The direction of magnetization shall be determined by particle indications obtained using an indicator or shims as shown in Fig. T-753.1.1 or Fig. T-753.1.2. When a clearly defined line of particles is not formed in the desired direction, the magnetizing technique shall be changed as needed.

T-753.2.1 For multidirectional magnetization techniques, the orientation of the lines of flux shall be in at least two nearly perpendicular directions. When clearly defined lines of particles are not formed in at least two nearly perpendicular directions, the magnetizing technique shall be changed as needed.

T-753.3 Determination of the adequacy and direction of magnetizing fields using magnetic field indicators or artificial flaws are only permitted when specifically referenced by the magnetizing technique in T-774.2(c), T-774.2(d), T-775.1(b)(3), T-775.2(a), T-775.2(b), and T-777.2.

T-754 Rectified Current A99

(a) Whenever direct current is required rectified current may be used. The rectified current for magnetization shall be either three-phase (full-wave rectified) current, or single phase (half-wave rectified) current.

(b) The amperage required with three-phase, full-wave rectified current shall be verified by measuring the average current.

(c) The amperage required with single-phase (half-wave rectified) current shall be verified by measuring the average current output during the conducting half cycle only.

(d) When measuring half-wave rectified current with a direct current test meter, readings shall be multiplied by two.

T-755 Demagnetization

When residual magnetism in the part could interfere with subsequent processing or usage, the part shall be demagnetized any time after completion of the examination.

A00 ### T-756 Postexamination Cleaning

When postexamination cleaning is required by the procedure, it should be conducted as soon as practical using a process that does not adversely affect the part.

T-760 CALIBRATION OF EQUIPMENT

A99 ### T-761 Frequency of Calibration

(a) Frequency. Each piece of magnetizing equipment with an ammeter shall be calibrated at least once a year, or whenever the equipment has been subjected to major electric repair, periodic overhaul, or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

(b) Procedure. The accuracy of the unit's meter shall be verified annually by equipment traceable to a national standard. Comparative readings shall be taken for at least three different current output levels encompassing the usable range.

(c) Tolerance. The unit's meter reading shall not deviate by more than ±10% of full scale, relative to the actual current value as shown by the test meter.

A00 ### T-762 Lifting Power of Yokes

(a) Prior to use, the magnetizing power of electromagnetic yokes shall have been checked within the past year. The magnetizing power of permanent magnetic yokes shall be checked daily prior to use. The magnetizing power of all yokes shall be checked whenever the yoke has been damaged or repaired.

(b) Each alternating current electromagnetic yoke shall have a lifting power of at least 10 lb (4.5 kg) at the maximum pole spacing that will be used.

(c) Each direct current or permanent magnetic yoke shall have a lifting power of at least 40 lb (18.1 kg) at the maximum pole spacing that will be used.

(d) Each weight shall be weighed with a scale from a reputable manufacturer and stenciled with the applicable nominal weight prior to first use. A weight need only be verified again if damaged in a manner that could have caused potential loss of material.

T-763 Gaussmeters A99

Hall-Effect probe gaussmeters used to verify magnetizing field strength in accordance with T-753 shall be calibrated at least once a year or whenever the equipment has been subjected to a major repair, periodic overhaul, or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

T-770 EXAMINATION

T-771 Direction of Magnetization

At least two separate examinations shall be performed on each area. During the second examination, the lines of magnetic flux shall be approximately perpendicular to those used during the first examination. A different technique for magnetization may be used for the second examination.

T-772 Examination Coverage A99

All examinations shall be conducted with sufficient field overlap to ensure 100% coverage at the required sensitivity (T-753).

T-773 Prod Technique

T-773.1 Magnetizing Procedure. For the prod technique, magnetization is accomplished by portable prod type electrical contacts pressed against the surface in the area to be examined. To avoid arcing, a remote control switch, which may be built into the prod handles, shall be provided to permit the current to be turned on after the prods have been properly positioned.

T-773.2 Magnetizing Current. Direct or rectified magnetizing current shall be used. The current shall be 100 (minimum) amp/in. to 125 (maximum) amp/in. of prod spacing for sections $^{3}/_{4}$ in. (19 mm) thick or greater. For sections less than $^{3}/_{4}$ in. (19 mm) thick, the current shall be 90 amp/in. to 110 amp/in. of prod spacing.

T-773.3 Prod Spacing. Prod spacing shall not exceed 8 in. (203 mm). Shorter spacing may be used to accommodate the geometric limitations of the area being examined or to increase the sensitivity, but prod spacings of less than 3 in. (76 mm) are usually not practical due to banding of the particles around the prods. The prod tips shall be kept clean and dressed. If the open circuit voltage of the magnetizing current source is greater than 25 V, lead, steel, or aluminum

(rather than copper) tipped prods are recommended to avoid copper deposits on the part being examined.

T-774 Longitudinal Magnetization Technique

T-774.1 Magnetizing Procedure. For this technique, magnetization is accomplished by passing current through a multi-turn fixed coil (or cables) that is wrapped around the part or section of the part to be examined. This produces a *longitudinal* magnetic field parallel to the axis of the coil.

If a fixed, prewound coil is used the part shall be placed near the side of the coil during inspection. This is of special importance when the coil opening is more than 10 times the cross-sectional area of the part.

A99 **T-774.2 Magnetic Field Strength.** Direct or rectified current shall be used to magnetize parts examined by this technique. The required field strength shall be calculated based on the length L and the diameter D of the part in accordance with (a), (b), or as established in (c), below. Long parts shall be examined in sections not to exceed 18 in. (457 mm), and 18 in. (457 mm) shall be used for the part L in calculating the required field strength. For noncylindrical parts, D shall be the maximum cross-sectional diagonal.

(a) Parts With L/D Ratios Equal to or Greater Than 4. The magnetizing current shall be within ±10% of the ampere-turns' value determined as follows:

$$\text{Ampere-turns} = \frac{35{,}000}{(L/D) + 2}$$

For example, a part 10 in. long × 2 in. diameter has an L/D ratio of 5. Therefore,

$$\frac{35{,}000}{(5 + 2)} = 5000 \text{ ampere-turns}$$

(b) Parts With L/D Ratios Less Than 4 but Not Less Than 2. The magnetizing ampere-turns shall be within ±10% of the ampere-turns' value determined as follows:

$$\text{Ampere-turns} = \frac{45{,}000}{L/D}$$

(c) If the area to be magnetized extends beyond 6 in. on either side of the coils, field adequacy shall be demonstrated using the magnetic field indicator per T-753.

(d) For large parts due to size and shape, the magnetizing current shall be 1200 ampere-turns to 4500 ampere-turns. The field adequacy shall be demonstrated using artificial flaw shims or a pie-shaped magnetic field indicator in accordance with T-753. A Hall-Effect probe gaussmeter shall not be used with encircling coil magnetization techniques.

T-774.3 Magnetizing Current. The current required to obtain the necessary magnetizing field strength shall be determined by dividing the ampere-turns obtained in steps (a) or (b) above by the number of turns in the coil as follows:

$$\text{Amperes (meter reading)} = \frac{\text{ampere-turns}}{\text{turns}}$$

For example, if a 5-turn coil is used and the ampere-turns required are 5000, use

$$\frac{5000}{5} = 1000 \text{ amperes } (\pm 10\%)$$

T-775 Circular Magnetization Technique

T-775.1 Direct Contact Technique A99

(a) Magnetizing Procedure. For this technique, magnetization is accomplished by passing current through the part to be examined. This produces a *circular* magnetic field that is approximately perpendicular to the direction of current flow in the part.

(b) Magnetizing Current. Direct or rectified (half-wave rectified or full-wave rectified) magnetizing current shall be used.

(1) The current shall be 300 amp/in. (12A/mm) to 800 amp/in. (31A/mm) of outer diameter.

(2) Parts with geometric shapes other than round with the greatest cross-sectional diagonal in a plane at right angles to the current flow shall determine the inches to be used in (b)(1) above.

(3) If the current levels required for (b)(1) cannot be obtained, the maximum current obtainable shall be used and the field adequacy shall be demonstrated in accordance with T-753.

T-775.2 Central Conductor Technique A99

(a) Magnetizing Procedure. For this technique, a central conductor is used to examine the internal surfaces of cylindrically or ring-shaped parts. The central conductor technique may also be used for examining the outside surfaces of these shapes. Where large diameter cylinders are to be examined, the conductor shall be positioned close to the internal surface of the cylinder. When the conductor is not centered, the circumference of the cylinder shall be examined in increments. Field strength measurements in accordance with T-753 shall be used to determine the extent of the arc that may be examined for each conductor position. Bars or cables, passed through the bore of a cylinder, may be used to induce circular magnetization.

(b) Magnetizing Current. The field strength required shall be equal to that determined in T-775.1(b) for a single-turn central conductor. The magnetic field will increase in proportion to the number of times the central conductor cable passes through a hollow part. For example, if 6000 amperes are required to examine a

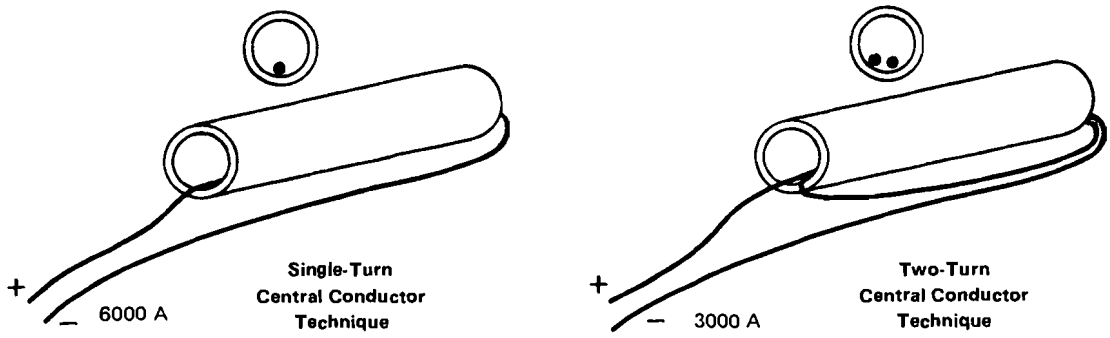


FIG. T-775.2 SINGLE-TURN AND TWO-TURN CENTRAL CONDUCTOR TECHNIQUE

part using a single central conductor, then 3000 amperes are required when 2 turns of the through-cable are used, and 1200 amperes are required if 5 turns are used (see Fig. T-775.2). When the central conductor technique is used, magnetic field adequacy shall be verified using a magnetic particle field indicator in accordance with T-753.

T-776 Yoke Technique

T-776.1 Application. This method shall only be applied to detect discontinuities that are open to the surface of the part.

T-776.2 Magnetizing Procedure. For this technique alternating or direct current electromagnetic yokes, or permanent magnet yokes, shall be used.

NOTE: Except for materials ¼ in. (6 mm) or less in thickness, alternating current yokes are superior to direct or permanent magnet yokes of equal lifting power for the detection of surface discontinuities.

T-777 Multidirectional Magnetization Technique

T-777.1 Magnetizing Procedure. For this technique magnetization is accomplished by high amperage power packs operating as many as three circuits that are energized one at a time in rapid succession. The effect of these rapidly alternating magnetizing currents is to produce an overall magnetization of the part in multiple directions. Circular or longitudinal magnetic fields may be generated in any combination using the various techniques described in T-774 and T-775.

A99 **T-777.2 Magnetic Field Strength.** Only three phase, full-wave rectified current shall be used to magnetize the part. The initial magnetizing current requirements for each circuit shall be established using the previously described guidelines (see T-774 and T-775). The adequacy of the magnetic field shall be demonstrated using artificial flaw shims or a pie-shaped magnetic particle field indicator in accordance with T-753. A Hall-Effect probe gaussmeter shall not be used to measure field adequacy for the multidirectional magnetization technique. An adequate field shall be obtained in at least two nearly perpendicular directions, and the field intensities shall be balanced so that a strong field in one direction does not overwhelm the field in the other direction. For areas where adequate field strengths cannot be demonstrated, additional magnetic particle techniques shall be used to obtain the required two-directional coverage.

T-778 Interpretation A99

T-778.1 Nonfluorescent Particles. With nonfluorescent particles, the examination is performed using visible light. A minimum light intensity of 50 fc (500 Lx) is required to ensure adequate sensitivity during the examination and evaluation of indications. A99

T-778.2 Fluorescent Particles. With fluorescent particles the examination is performed using an ultraviolet light, called *black light.* The examination shall be performed as follows: A99

(a) It shall be performed in a darkened area.

(b) The examiner shall be in the darkened area for at least 5 min prior to performing the examination to enable his eyes to adapt to dark viewing. If the examiner wears glasses or lenses, they shall not be photosensitive.

(c) The black light shall be allowed to warm up for a minimum of 5 min prior to use or measurement of the intensity of the ultraviolet light emitted.

(d) The black light intensity shall be measured with a black light meter. A minimum of 1000 $\mu W/cm^2$ on the surface of the part being examined shall be required. The black light intensity shall be measured at least once every 8 hr, and whenever the work station is changed.

T-780 EVALUATION

(a) All indications shall be evaluated in terms of the acceptance standards of the referencing Code Section.

(b) Discontinuities on or near the surface are indicated by retention of the examination medium. However, localized surface irregularities due to machining marks or other surface conditions may produce false indications.

(c) Broad areas of particle accumulation which might mask indications from discontinuities are prohibited, and such areas shall be cleaned and reexamined.

T-790 RECORDS

T-791 Multidirectional Magnetization Technique Sketch

A technique sketch shall be prepared for each different geometry examined, showing the part geometry, cable arrangement and connections, magnetizing current for each circuit, and the areas of examination where adequate field strengths are obtained. Parts with repetitive geometries, but different dimensions, may be examined using a single sketch provided that the magnetic field strength is adequate when demonstrated in accordance with T-777.2.

ARTICLE 7
MANDATORY APPENDICES

APPENDIX I — MAGNETIC PARTICLE EXAMINATION ON COATED FERRITIC MATERIALS USING THE AC YOKE TECHNIQUE

I-710 SCOPE

This Appendix provides the Magnetic Particle examination methodology and equipment requirements applicable for performing Magnetic Particle examination on coated ferritic materials.

I-720 GENERAL

I-721 Personnel Qualification

Personnel qualification requirements shall be in accordance with the referencing Code Section.

I-730 EQUIPMENT

A99 **I-730.1** The magnetizing equipment shall be in accordance with Article 7.

A99 **I-730.2** When the dry powder technique is used, a powder blower shall be utilized for powder application. Hand squeezed particle applicators shall not be used when the dry powder technique is utilized.

I-730.3 Magnetic particles shall contrast with the component background.

I-730.4 Nonconductive materials such as plastic shim stock may be used to simulate nonconductive coatings for procedure and personnel qualification.

I-750 PROCEDURE/TECHNIQUE

I-750.1 Procedure

Magnetic particle examination shall be performed in accordance with a written procedure. The procedure shall include the following:

(a) identification of surface configurations to be examined, including coating materials, maximum qualified coating thickness, and product forms (e.g., base material or welded surface)

(b) surface condition requirements and preparation methods

(c) manufacturer and model of AC yoke

(d) manufacturer and type of magnetic particles

(e) minimum and maximum yoke leg separation

(f) method of measuring coating thickness

(g) identification of the steps in performing the examination

(h) minimum lighting and AC yoke lifting power requirements (as measured in accordance with Procedure Qualification I-752)

(i) methods of identifying flaw indications and discriminating between flaw indications and nonrelevant indications (e.g., magnetic writing or particle held by surface irregularities)

(j) instructions for identification and confirmation of suspected flaw indications

(k) recording criteria

(l) personnel qualification requirements

(m) reference to the procedure qualification records

(n) method of verifying that the yoke lifting power and the illumination source used in the production examination are at least as great as specified.

I-751 Coating Thickness Measurement

The procedure demonstration and performance of examinations shall be preceded by measurement of the coating thickness in the areas to be examined. If the coating is nonconductive, an eddy current technique may be used to measure the coating thickness. If the

coating is conductive, a magnetic coating thickness technique shall be used in accordance with ASTM D1186. Coating measurement equipment shall be used in accordance with the equipment manufacturer's instructions. Coating thickness measurements shall be taken at the intersections of a 2 in. (51 mm) maximum grid pattern over the area of examination and at least one-half the maximum yoke leg separation beyond the examination area. The thickness shall be the mean of three separate readings within $\frac{1}{4}$ in. (6 mm) of each intersection.

I-752 Procedure Demonstration

The procedure shall be demonstrated to the satisfaction of the Inspector in accordance with the requirements of the referencing Code Section.

I-753 Procedure Qualification

(a) A qualification specimen is required. The specimen shall be of similar geometry or weld profile and contain at least one surface crack no longer than the maximum flaw size allowed in the applicable acceptance criteria. The material used for the specimen shall be the same specification and heat treatment as the coated ferromagnetic material to be examined. As an alternative to the material requirement, other materials and heat treatments may be qualified provided:

(1) The measured yoke maximum lifting force on the material to be examined is equal to or greater than the maximum lifting force on the qualification specimen material. Both values shall be determined with the same or comparable equipment and shall be documented as required in paragraph (c).

(2) All the requirements of paragraphs *(b)* through *(g)* are met for the alternate material.

(b) Examine the uncoated specimen in the most unfavorable orientation expected during the performance of the production examination.

(c) Document the measured yoke maximum lifting power, illumination levels, and the results.

(d) Measure the maximum coating thickness on the item to be examined in accordance with the requirements of I-751.

(e) Coat the specimen with the same type of coating, conductive or nonconductive, to the maximum thickness measured on the production item to be examined. Alternately, nonconductive shim stock may be used to simulate nonconductive coatings.

(f) Examine the coated specimen in the most unfavorable orientation expected during the performance of the production examination. Document the measured yoke maximum lifting power, illumination level, and examination results.

(g) Compare the length of the indication resulting from the longest flaw no longer than the maximum flaw size allowed by the applicable acceptance criteria, before and after coating. The coating thickness is qualified when the length of the indication on the coated surface is at least 50% of the length of the corresponding indication prior to coating.

(h) Requalification of the procedure is required for a decrease in either the AC yoke lifting power or the illumination level, or for an increase in the coating thickness.

I-770 EXAMINATION

(a) Surfaces to be examined, and all adjacent areas within at least 1 in. (25 mm), shall be free of all dirt, grease, lint, scale, welding flux and spatter, oil, and loose, blistered, flaking, or peeling coating.

(b) Examine the coated item in accordance with the qualified procedure.

I-780 EVALUATION

If an indication greater than 50% of the maximum allowable flaw size is detected, the coating in the area of the indication shall be removed and the examination repeated.

I-790 DOCUMENTATION/RECORDS

Procedure qualification documentation shall include the following:

(a) identification of the procedure

(b) identification of the personnel performing and witnessing the qualification

(c) description and drawings or sketches of the qualification specimen, including coating thickness measurements and flaw dimensions

(d) equipment and materials used

(e) illumination level and yoke lifting power

(f) qualification results, including maximum coating thickness and flaws detected.

APPENDIX II — GLOSSARY OF TERMS FOR MAGNETIC PARTICLE EXAMINATION

II-710 SCOPE

This Mandatory Appendix is used for the purpose of establishing standard terms and definition of terms which appear in Article 7, Magnetic Particle Examination.

II-720 GENERAL REQUIREMENTS

(a) The Standard Terminology for Nondestructive Examinations (ASTM E 1316) has been adopted by the Committee as SE-1316.

(b) SE-1316 Section G provides the definitions of terms listed in II-730(a).

(c) For general terms, such as *Indication, Flaw, Discontinuity, Evaluation*, etc., refer to Article 1, Mandatory Appendix 1.

(d) Paragraph II-730(b) provides a list of terms and definitions which are in addition to SE-1316 and are Code specific.

II-730 REQUIREMENTS

(a) The following SE-1316 terms are used in conjunction with this Article: ampere turns, black light, central conductor, circular magnetization, demagnetization, dry powder, full-wave direct current, half-wave current, longitudinal magnetization, magnetic field, magnetic field strength, magnetic particle examination, magnetic particle field indicator, magnetic particles, multidirectional magnetization, permanent magnet, prods, sensitivity, suspension, yoke.

(b) The following Code terms are used in conjunction with this Article:

black light intensity — a quantitative expression of ultraviolet irradiance

magnetic flux — the concept that the magnetic field is flowing along the lines of force suggests that these lines are therefore "flux" lines, and they are called magnetic flux. The strength of the field is defined by the number of flux lines crossing a unit area taken at right angles to the direction of the lines.

rectified magnetic current — by means of a device called a rectifier, which permits current to flow in one direction only, alternating current can be converted to unidirectional current. This differs from direct current in that the current value varies from a steady level. This variation may be extreme, as in the case of the half-wave rectified single phase AC, or slight, as in the case of three-phase rectified AC.

half-wave rectified current AC — when a single-phase alternating current is rectified in the simplest manner, the reverse of the cycle is blocked out entirely. The result is a pulsating unidirectional current with intervals when no current at all is flowing. This is often referred to as "half-wave" or pulsating direct current.

full-wave rectified current — when the reverse half of the cycle is turned around to flow in the same direction as the forward half. The result is full-wave rectified current. Three-phase alternating current when full-wave rectified is unidirectional with very little pulsation; only a ripple of varying voltage distinguishes it from straight DC single-phase, full rectified current is usually not employed for magnetic particle examination.

ARTICLE 7
NONMANDATORY APPENDIX

A99

APPENDIX A — MEASUREMENT OF TANGENTIAL FIELD STRENGTH WITH GAUSSMETERS

A-710 SCOPE

This Nonmandatory Appendix is used for the purpose of establishing procedures and equipment specifications for measuring the tangential applied magnetic field strength.

A-720 GENERAL REQUIREMENTS

Personnel qualification requirements shall be in accordance with Article 1.

Gaussmeters and related equipment shall be calibrated in accordance with T-763 of Article 7.

Definitions: standard terminology for magnetic particle examinations is presented in SE-1316.

A-730 EQUIPMENT

Gaussmeter having the capability of being set to read peak values of field intensity. The frequency response of the gaussmeter shall be at least 0 Hz to 300 Hz.

The Hall-Effect tangential field probe should be no larger than 0.2 in. (5 mm) by 0.2 in. (5 mm) and should have a maximum center location 0.2 in. (5 mm) from the part surface. Probe leads shall be shielded or twisted to prevent reading errors due to voltage induced during the large field changes encountered during magnetic particle examinations.

A-750 PROCEDURE

Care must be exercised when measuring the tangential applied field strengths specified in T-753.1.3. The plane of the probe must be perpendicular to the surface of the part at the location of measurement to within 5 deg. This may be difficult to accomplish by hand orientation. A jig or fixture may be used to ensure this orientation is achieved and maintained.

The direction and magnitude of the tangential field on the part surface can be determined by placing the Hall-Effect tangential field probe on the part surface in the area of interest. The direction of the field can be determined during the application of the magnetizing field by rotating the tangential field probe while in contact with the part until the highest field reading is obtained on the Gaussmeter. The orientation of the probe, when the highest field is obtained, will indicate the field direction at that point. Gaussmeters cannot be used to determine the adequacy of magnetizing fields for multidirectional and coil magnetization techniques.

Once adequate field strength has been demonstrated with artificial flaw shims, Gaussmeter readings may be used at the location of shim attachment on identical parts or similar configurations to verify field intensity and direction.

A-790 DOCUMENTATION/RECORDS

Documentation should include the following:

(a) equipment model and probe description;

(b) sketch or drawing showing where measurements are made; and

(c) field intensity and direction of measurement.