VITRODIMENSIONS
Vitro Fibras del Sureste, S.A. de C.V.
A Division of Copilot Offshore, S.A. de C.V.

REPORTE DE INSPECCION DIMENSIONAL / DIMENSIONAL INSPECTION REPORT

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SERIAL NUMBER / NUMERO DE SERIE: CO-VFS-01/15
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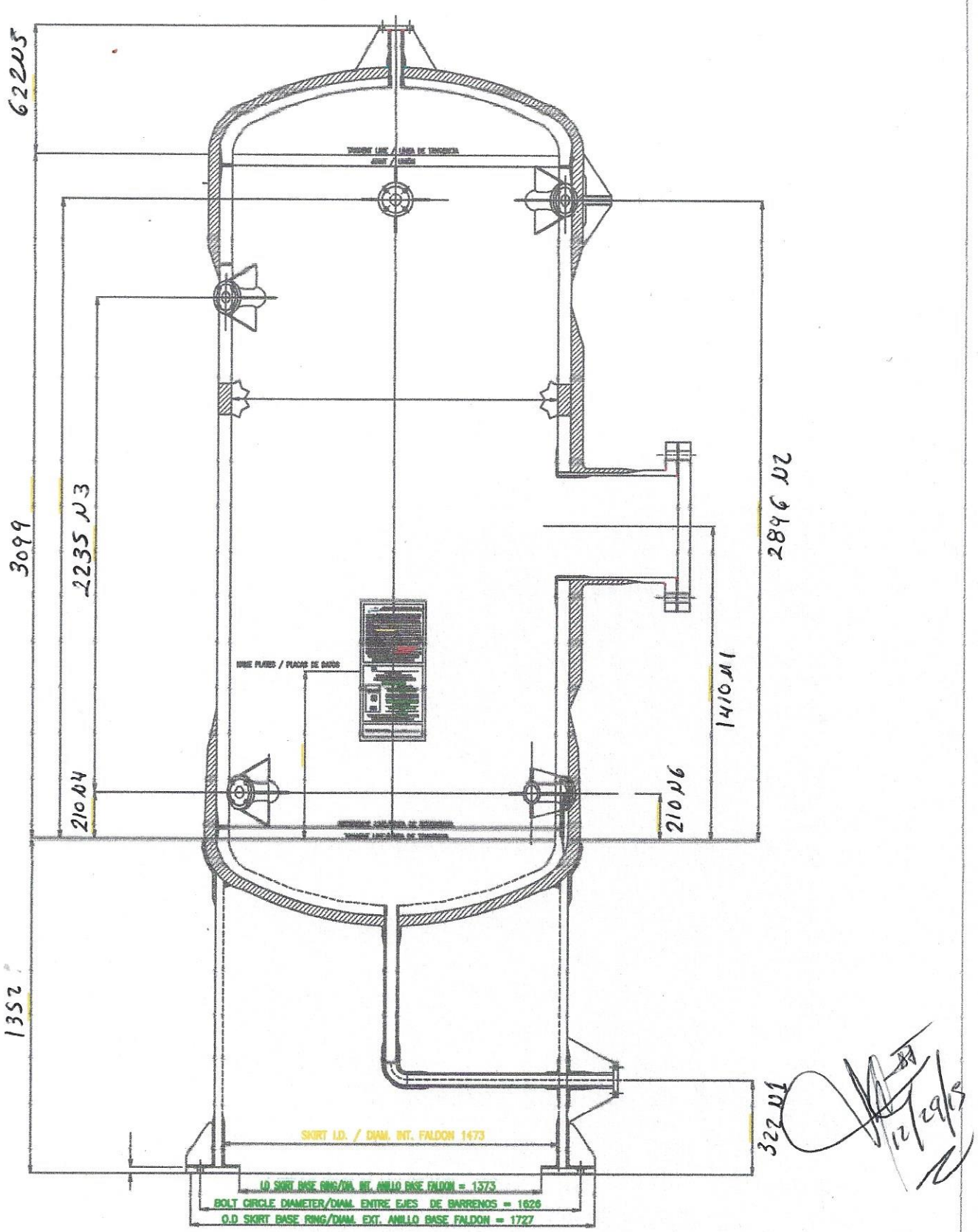

12/29/15

VERIFIED BY/VERIFICADO POR: 27/12/15
AUTHORIZED INSPECTOR/INSPECTOR AUTORIZADO

APPROVED BY/APROBADO POR: 27/12/15
QUALITY ASSURANCE MANAGER/GERENTE DE ASEGURAMIENTO DE CALIDAD

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TEST PROCEDURES/ Procedimiento de pruebas.

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REVISIONS CONTROL		
Revision No.	Date:	Change or Modification Description
0	DECEMBER 06,2012	First Edition does not apply

1.0 PURPOSE

1.1 This procedure defines the minimum requirements and activities that will be carried out for the performance of the hydrostatic test of fiber reinforced plastic pressure vessel fabricated in VITROFIBRAS DEL SURESTE, S.A. de C.V. A DIVISION OF COPIISA OFFSHORE, S.A. de C.V.

2.0 SCOPE

2.1 This procedure applies to hydrostatic test of pressure vessels designed and manufactured by VITROFIBRAS DEL SURESTE, S.A. de C.V. A DIVISION OF COPIISA OFFSHORE, S.A. de C.V. under the requirements of ASME Code Section X

Note: In this procedure specifically the word "vessel" should define the equipment or part of equipment to be tested hydrostatically including shell, nozzles, reinforcements pad, etc.

3.0 RESPONSIBILITIES

3.1 The Quality Control Inspector shall verify that the hydrostatic test performance is made as specific in this procedure.

3.2 The Quality Control Inspector shall to record the results of the hydrostatic test in the exhibit 2.4.

3.3 The Quality Control Inspector shall verify that the repairs fulfill the code requirements

3.4 The Production Manager shall to performance the hydrostatic test.

3.5 The Quality Assurance Manager shall check and approve the results of the tests

3.6 The Production Manager has the responsibility of performance any repair required by the Quality Assurance Manager.

3.7 The Engineer Manager has the responsibility of establishing and registered the pressure test in the drawing fabrication.

3.8 The Quality Assurance Manager has the responsibility to assigned only calibrated gages for performance hydrostatic test.

3.9 The Quality assurance Manager has the responsibility notify to the Authorized Inspector ASME of date test.

3.10 The Authorized Inspector ASME has the responsibility for witness the hydrostatic test and signed the records.

4.0 REFERENCES

4.1 Quality Assurance System Manual

4.2 ASME Code Section X

a) Article RT-5 Hydrostatic Test Procedure and Equipment for Class II Vessel

b) Article RT-6 Acceptance Test Procedure

4.3 ASME Code Section V Article 11 Acoustic Emission Examination of Fiber-Reinforced Plastic Vessel

5.0 DEFINITIONS

5.1 **Hydrostatic Test**: The hydrostatic test is intended to verify that a vessel is free of structural defects and is suitable for the pressure and temperature for which is designed. This test is performance using water to pressure of 1.1 times the internal design pressure.

Note: The tests may be with pressures above to the indicated only when required for the customer.

6.0 DEVELOPMENT

6.1 GENERAL

Before applying pressure, the test equipment shall be examined to see that it is tight and that all low pressure filling lines and other appurtenances that should not be subjected to the test pressure have been disconnected or isolated by valves or other suitable means.

6.2 VESSEL PREPARATION

6.2.1 Any vessel to be tested hydrostatically should comply with following requirements:

a) The vessel should be 100% finished, including accessories, reinforcement pads, and the reparations required.

b) Before filled the vessel, this shall are in their operation position and supported with good engineering practices. In any special circumstances that this can not be achieved, special considerations should be taken in order to not alter or physically deform the vessel. For this reason it should be ensured.

c) If the vessel requires a finish such as paint this should be performed preferably after the hydrostatic test.

d) Vents shall be provided at all high points of the vessel in the test position to purge possible air pockets while the vessel is being filled with the test fluid

6.3 MATERIALS AND EQUIPMENT

6.3.1 Test Gages: The test gages to use shall be calibrated and the warranty of calibration will not exceed six months or more.

6.3.2 Thermometer with range from 0 to 100°C and accuracy of 1°C

6.3.3 Pressure source such as pump or other device

6.3.4 Miscellaneous (cotton waste, piping and connection (coupling), light, pencil of indelible paint, blind flanges, etc.)

6.4 TEST GAGE

6.4.1 An indicating gage shall be connected directly to the vessel. If the indicating gage is not readily visible to the operator controlling the pressure applied, an additional indicating gage shall be provide where will be visible to the operator throughout the duration of the text. For large vessels, it is recommended that a recording gage be used in addition to indicating gages.

6.4.2 Dial indicating pressure gages used in testing shall be graduated over a range of about double the intended maximum test pressure, but in no testing shall the range be less than 11/2 nor more that 4 times that pressure. A digital reading pressure gage having a wider range of pressure may be used provided the readings give the same or greater degree of accuracy as obtained with a dial pressure gage witch meets the above range requirement of 11/2 to 4 times the maximum test pressure.

6.5 TEST PERFOMANCE

6.5.1 The Production Manager or designed shall examined the vessel to see that is right and that all low pressure filling lines and other appurtenances that not subject to the pressure test have been disconnected or isolated by valves or other suitable means

6.5.2 Performed the activities above the Production Manager or your designed may be procedure to filling of the vessel used water potable.

Note: The filling inlet should be at the lowest nozzle or as near to the bottom of the vessel as possible.

6.5.3 The water used for the test shall be as specific in a) or b) below

a) For vessel with a design operating temperature at or below 120 °F (50°C), the temperature of the water shall be 120 °F (50°C) or less. ~~MIN 5 °C~~, BUT NOT

b) For vessel with a design operating temperature greater than 120 °F (50°C), the temperature of the water shall be within +5/-10 °F (+/-2.8°C) of the design operating temperature

6.5.4 After that the vessel was filled, this shall be purged up to not observed air outlet in the purge valve.

6.5.5 Purged the vessel, an indicating gage shall be connected directly to the vessel. If the indicating gage is not readily visible to the operator controlling the pressure applied, an additional indicating gage shall be provided where it will be visible to the operator throughout the duration of the test.

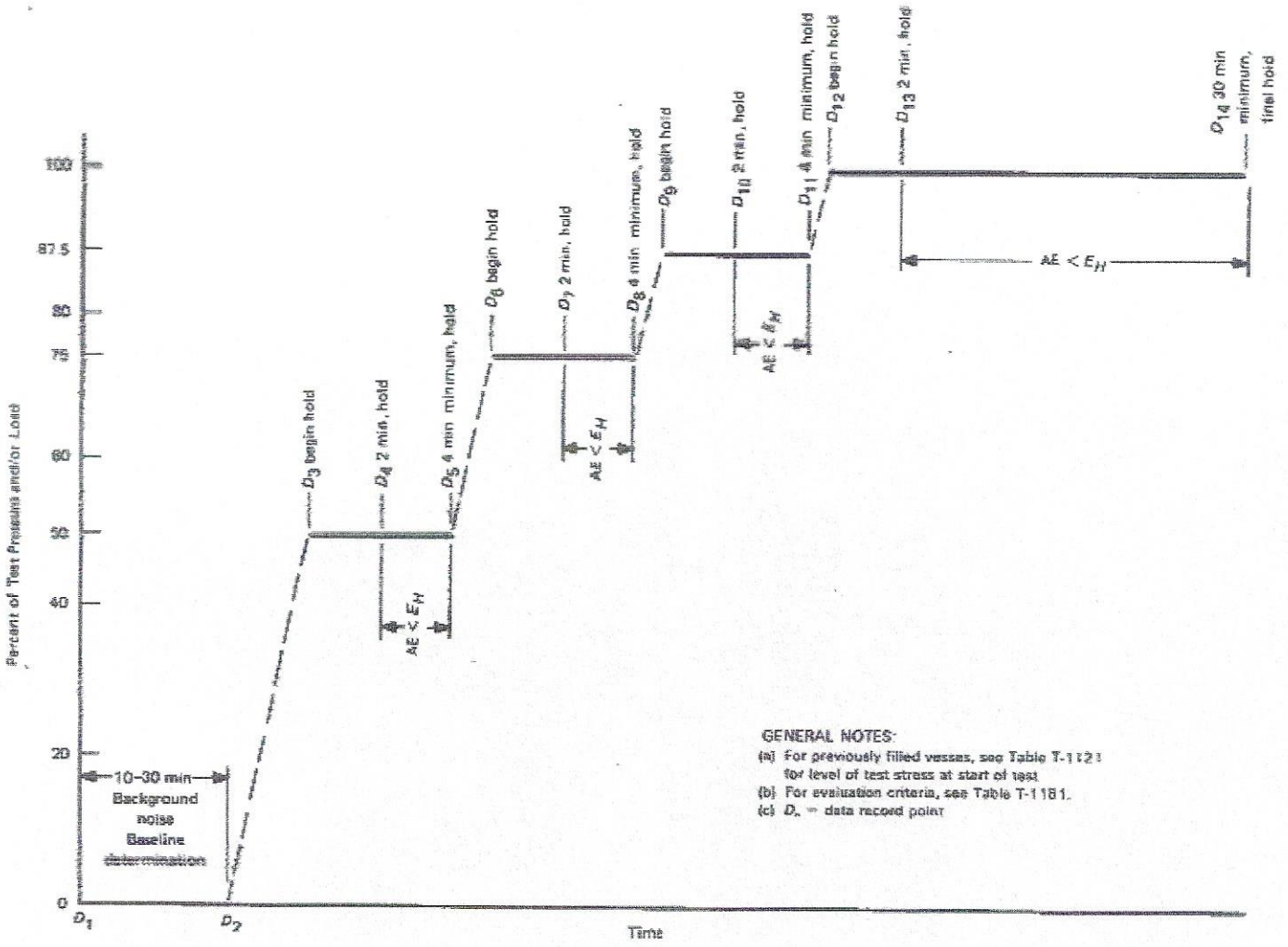
6.5.6 To connect the recording gage pressure in addition to indicating gages in a nozzle of vessel.

6.5.7 The vessel shall be subjected to programmed increasing stress levels to 1.1 times the internal pressure while being monitored by sensors that detect acoustic emission (stress waves) caused by growing structural imperfections

6.5.8 With the pump pressurize the vessel not exceeding a rate of 2% of the maximum test pressure per minute up to obtain the pressure indicated in the drawings of construction.

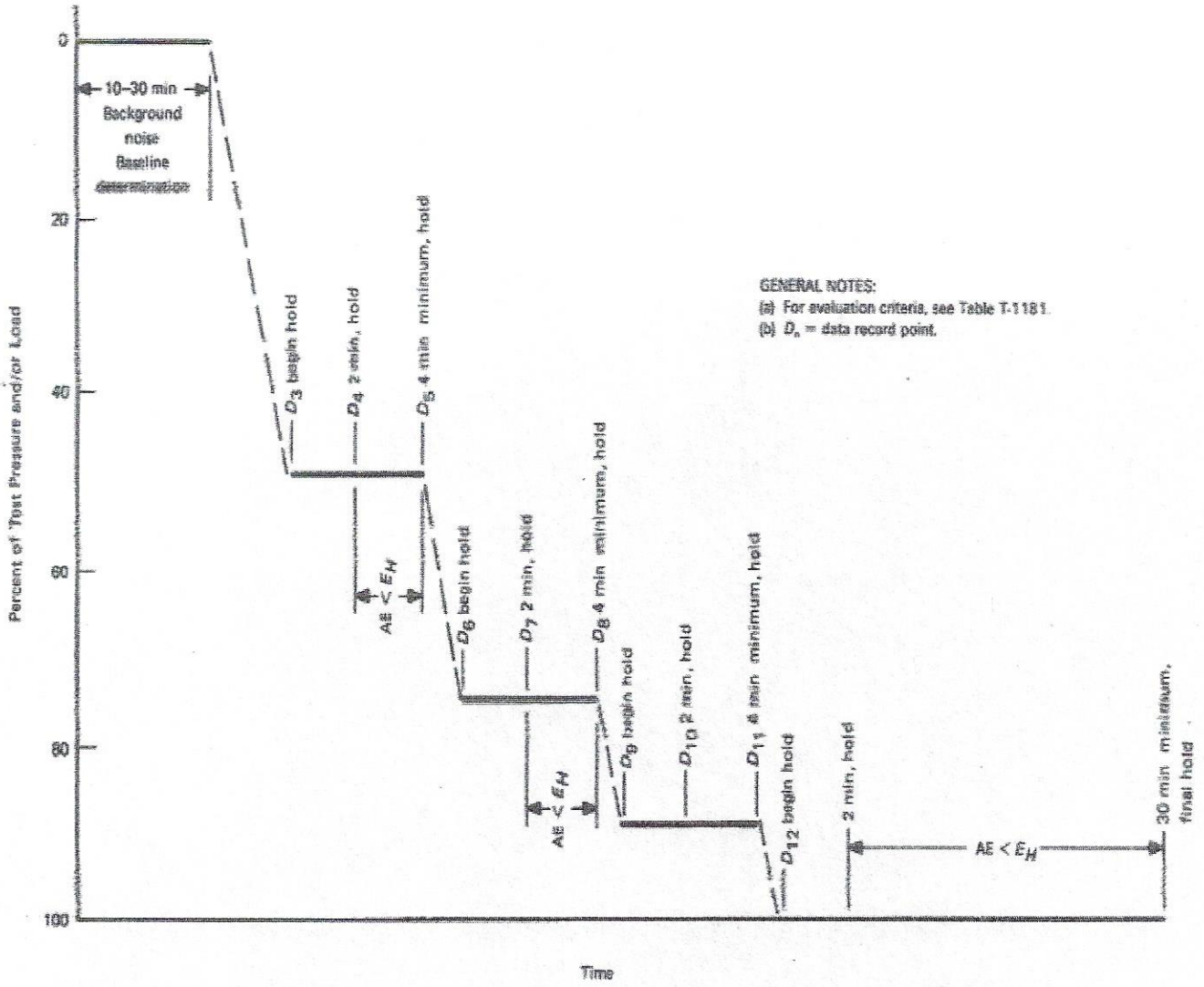
6.5.9 Vessels which are designed for internal pressure only shall be pressurized in accordance with the sequence shown in Section V, Article 11, and following figure.

FIG. T-1142(c)(1)(a) ATMOSPHERIC VESSELS STRESSING SEQUENCE (ASME SETION V ART. 11)



6.1.1 Vessels intended for both internal and external pressure only shall be pressurized in accordance with the sequence shown in Section V, Article 11, and fig. T-1142 (c)(1)(b). In addition, the vessel shall be tested to the requirements of RT-621

FIG. T-1142(c)(1)(b) VACUUM VESSELS STRESSING SEQUENCE (ASME SETION V ART. 11)



6.1.2 The first loading criteria shall apply if the vessel has not been pressurize to greater than 90% of the pressure prior to the test. Otherwise the vessel shall be evaluated against subsequent loading criteria and prior to testing shall be conditioned by holding at reduced pressure as required in the Section V, Article 11, Paragraph T-1121

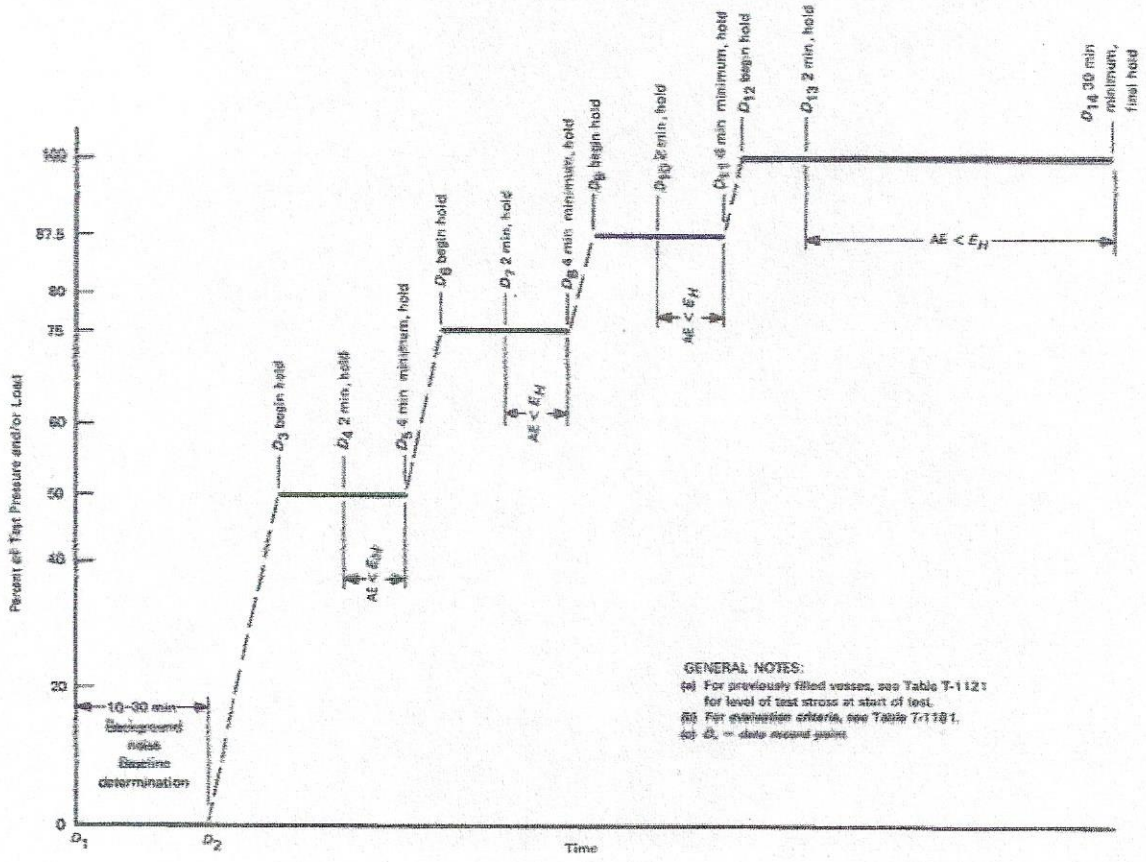
TABLE T-1121 (ASME SECTION V ARTICLE 11)
REQUIREMENTS FOR REDUCED OPERATING LEVEL
IMMEDIATELY PRIOR TO EXAMINATION

Percent of Operating Maximum Pressure and/or Load	Time Spent at Percent of Maximum Pressure and/or Load
10 or less	12 hr
20	18 hr
30	30 hr
40	2 days
50	4 days
60	7 days

EXAMPLE: For an inservice vessel, two factors must be known prior to making a test:
(1) The maximum operating pressure or load during the past year
(2) The test pressure

6.1.3 If a vessel is unacceptable by the first loading criteria, it may be retested and judged against the criteria for subsequent loadings. Prior to retest, the vessel shall be conditioned by holding at reduced pressure as required in Section V, Article 11, Paragraph T-1121 the pressure vessel stressing sequence for the retest may be to Section V, Article 11, Figure T-1142

FIG. T-1142(SI) ATMOSPHERIC VESSELS STRESSING SEQUENCE (ASME SECTION V ART. 11)



6.1.4 External test pressure shall be 1.0 times the external design pressure

6.1.5 Obtained the pressure test; the Quality Control Inspector and Authorized Inspector ASME shall be performance to inspection of the vessel. Leakage or watering shall not occur during the Acceptance Test.

6.1.6 Sufficient time shall be allowed before the start of the test (acoustic emission test) for the temperature of vessel and the water test to reach equilibrium.

6.1.7 The minimum acceptable vessel wall temperature is 40°F (5°C) during the examination.

6.1.8 Noise elimination

Noise sources in the test frequency and amplitude range, such as rain, spargers, and foreign objects contacting the vessel, must be minimize since they mask the Acoustic Emission signals emanating from the structure.

Note: The acoustic emission examination procedure shall be in accordance with Section V, article 11

6.1.9 Finished the inspection, the quality control inspector shall notify to the Production Manager or your designed for they procedure to depressurized to equipment and retract the devices used

6.2 RESULTS RECORDING

6.2.1 The finished test, the Quality Control Inspector shall be record the results in the exhibit 2.4; and turned to Quality Assurance Manager for reviewed and approval. The Quality Control Inspector shall notify to the Production Manager or designed of the results test.

Note: In addition to the chart test recording by the monograph, the quality control manager may be record the pressure in manner "schematic" in the exhibit 2.4

6.2.2 Any defect to observe during the test shall be marked by the Quality Control Inspector. The Quality Control Inspector shall be record and required to Production Manager the repair of the defect. The exhibit 5 shall be used for the record and required repair

6.3 REPAIRED VESSEL

The following procedure shall be used to retest a vessel that as been tested under provisions of article RT-6 and has subsequently been repaired.

a) Load the vessel as specified here without monitoring for acoustic emission.
b) Hold the maximum load for at lest 30 minutes
c) Condition the vessel by holding at reduced load as required by Section V, Article 11, T-1121
d) Retest the vessel as required in 6.4 of this procedure
e) The vessel shall be judged against the evaluation criteria for subsequent loadings

7.0 FORMS FOR RECORDS

7.1 Exhibit 2.4 "Acceptance Test Report"

7.2 Exhibit 5 "Nonconformance Report"

8.0 STRESSING

8.1 Atmospheric Vessel Loading.Sressing sequences for new atmospheric vessels and vacuum vessels are Shown in Figs. T-1142(c)(1)(a) and(b).The test algorithm-flow-chart for this class of vessels is given in Fig. T-1142(c)(1)(c).

8.2 Pressure Vessel Stressing.Pressure vessels which operate with superimposed pressures greater than 15 psi (100 kPa) above atmospheric shall be stressed as shown in Fig. T-1142(c)(1)(a).The test algorithm flowchart for this class of tanks is given in T-1142(c)(2)(b).

8.3 For all vessels,the final stress hold shall be for 30 min.The vessel should be monitored continuously during this period.

8.3.1 AE Activity.If significant (see T-1183(b))AE activity is detected during the test on low frequency channels,and not on high frequency,the examiner may relocate the high frequency channels.

8.3.2 Test Termination. Departure from a linear count / load relationship shall signal caution .If the AE count rate increases rapidly with load,the vessel shall be unloaded and the test terminated.(A rapidly (exponentially) increasing count rate indicates uncontrolled continuing damage and is indicative of impeding failure)

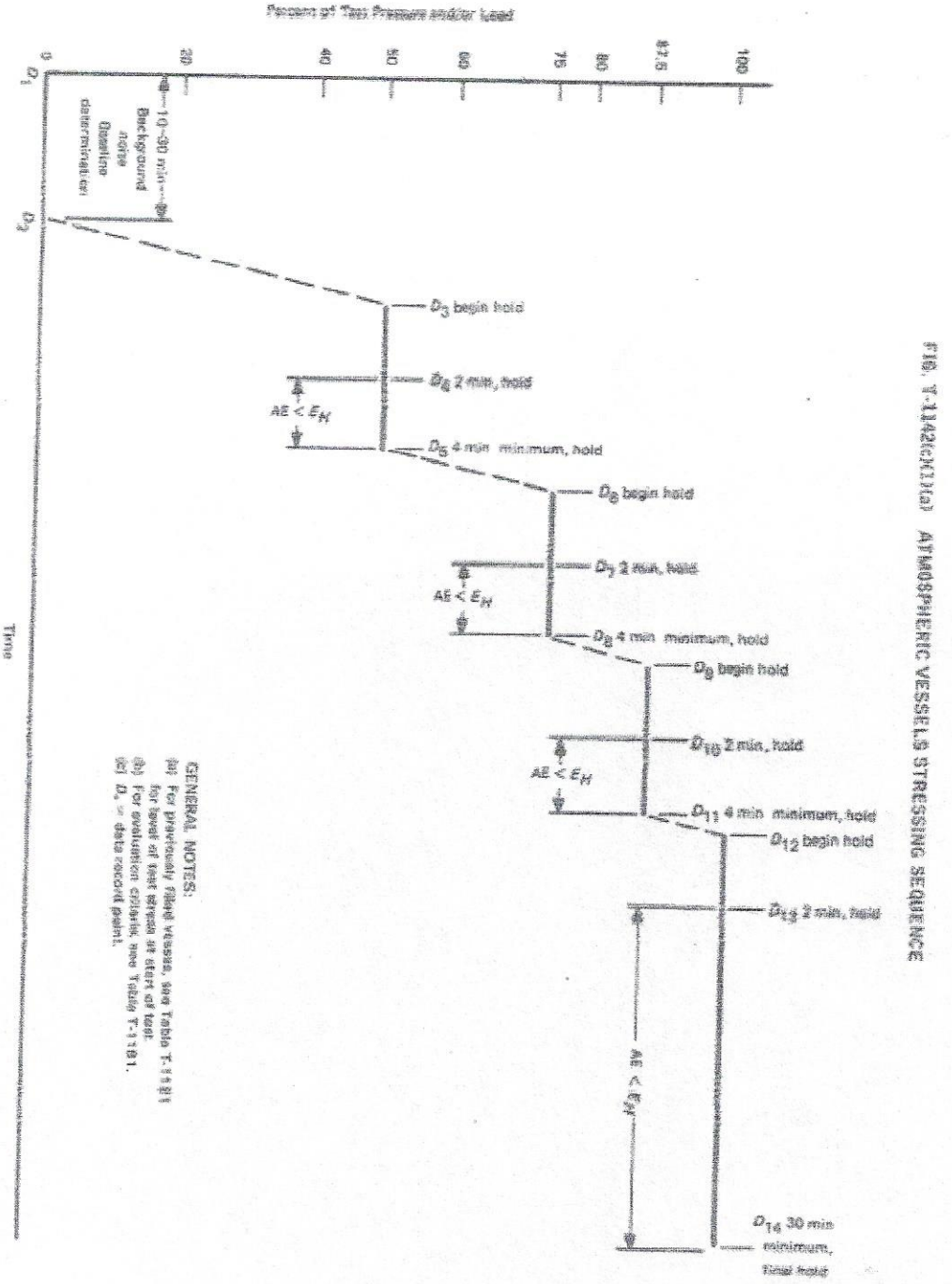
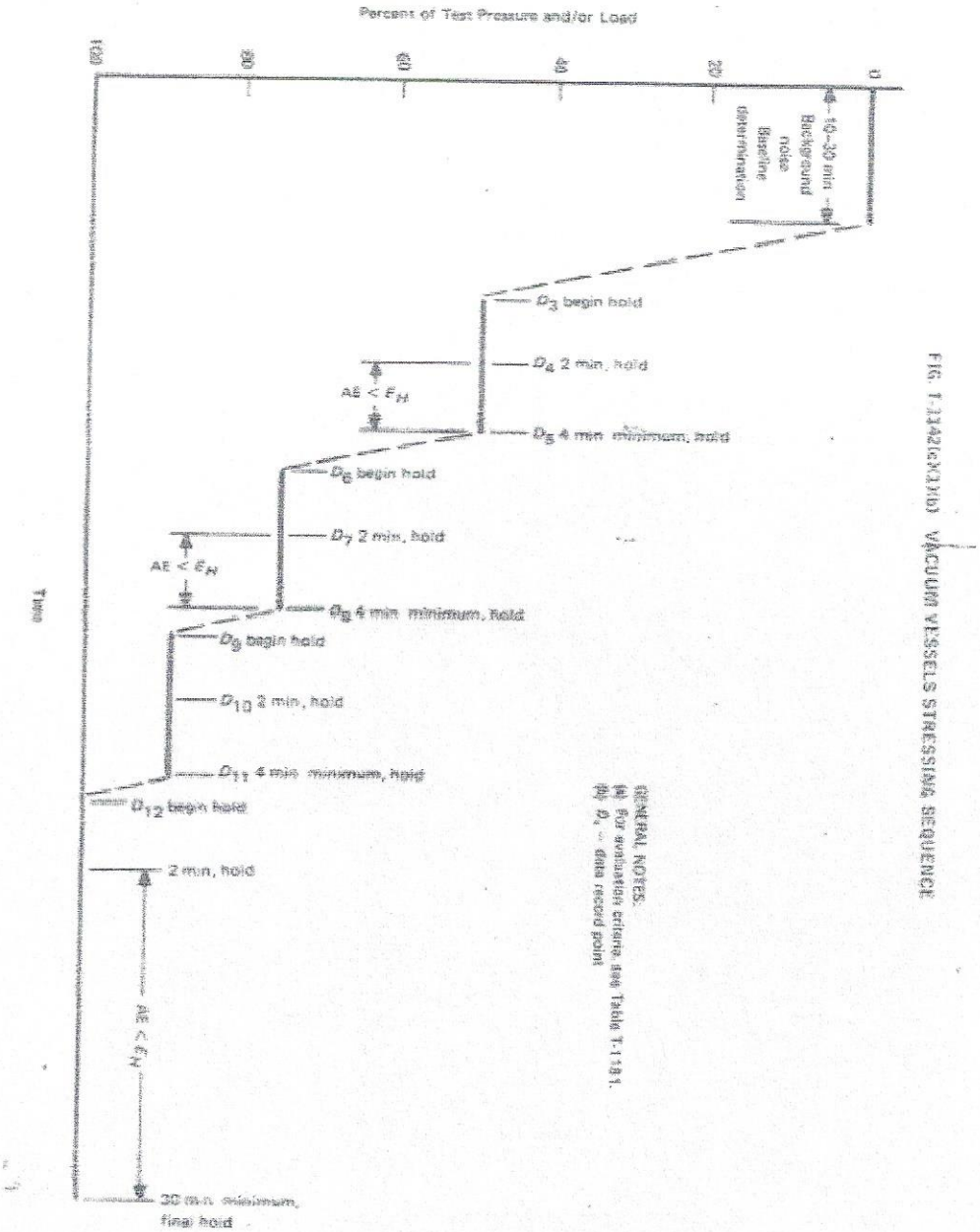


FIG. T-1142(c)(1)(a) ATMOSPHERIC VESSELS STRESSING SEQUENCE

GENERAL NOTES:
(a) For previously filled vessels, see Table T-1181.
(b) For evaluation criteria, see Table T-1181.
(c) D_1 = data record point.


Percent of Test Pressure and/or Load
100
90
75
50
25
0
10–30 min – background noise determination
D_3 begin hold
D_4 2 min. hold
$\Delta E < E_H$
D_5 4 min. minimum, hold
D_6 begin hold
D_7 2 min. hold
$\Delta E < E_H$
D_8 4 min. minimum, hold
D_9 begin hold
D_{10} 2 min. hold
D_{11} 4 min. minimum, hold
D_{12} begin hold
2 min. hold
$\Delta E < E_H$
30 min. minimum, final hold
Time
GENERAL NOTES:
(a) For evaluation criteria see Table T-1181.
(b) D_1 – data record point
FIG. T-1182(c)(1)(b) VACUUM VESSELS STRESSING SEQUENCE

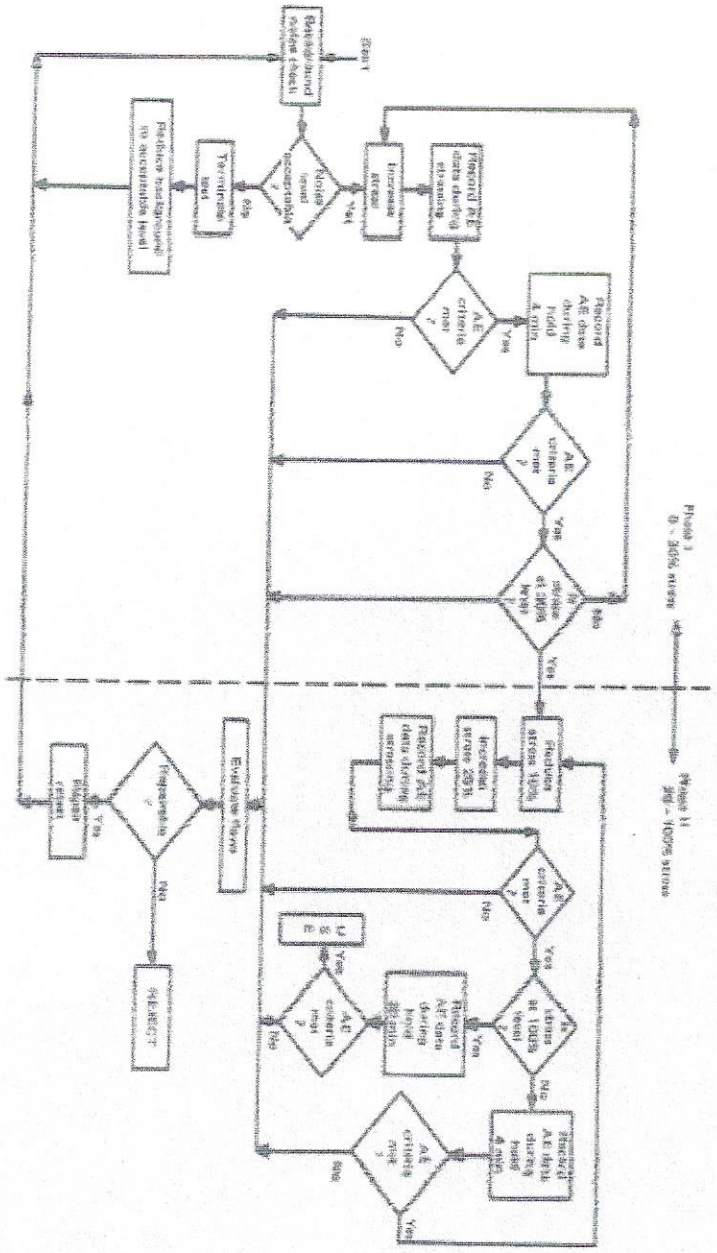


FIG. T-1126(c)(2)(b) ALGORITHM — FLOWCHART FOR PRESSURE VESSELS

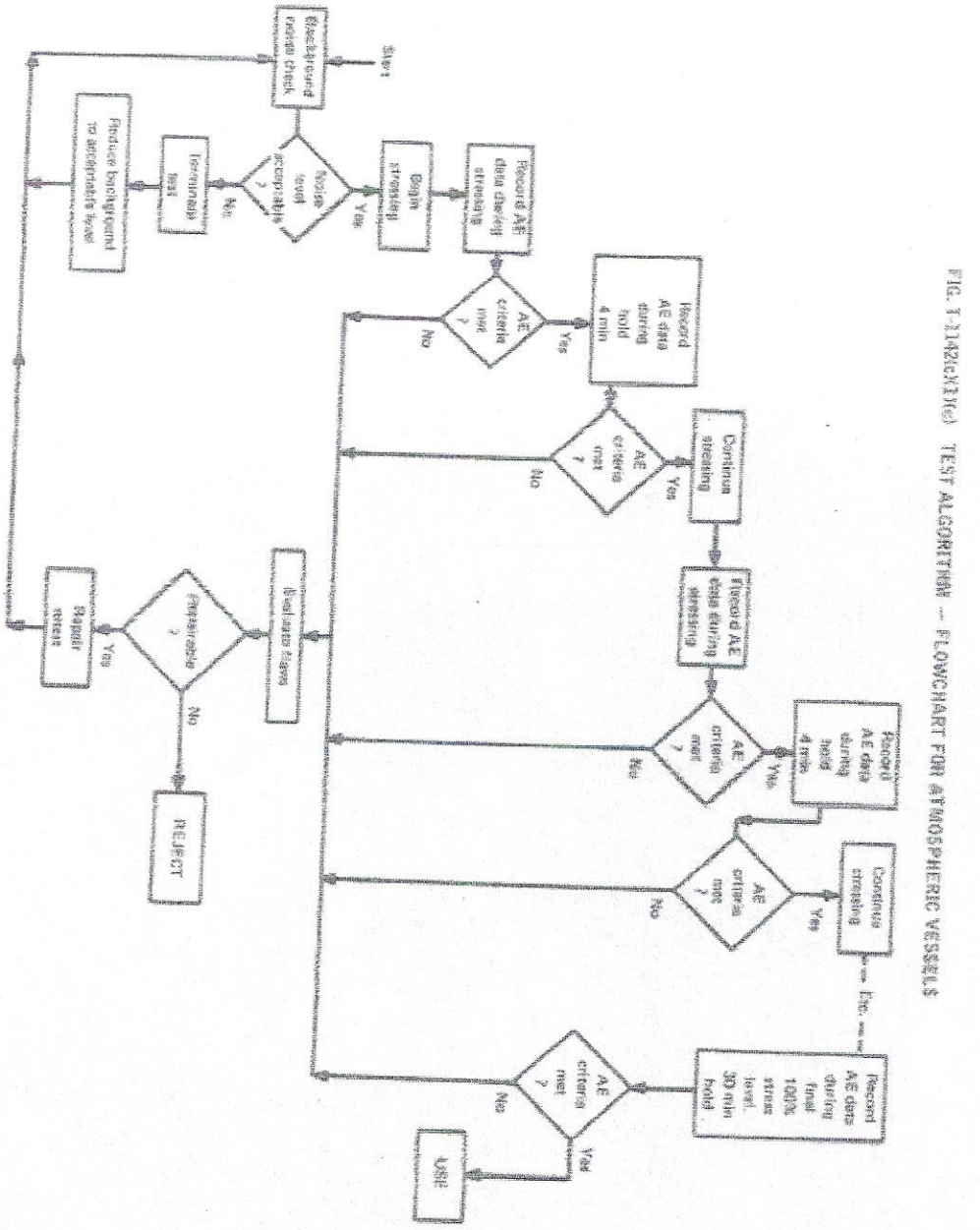


FIG. T-1142(a)(1)(c) TEST ALGORITHM — FLOWCHART FOR ATMOSPHERIC VESSELS

COPIISA OFFSHORE VITRODISEÑOS. CREATIVIDAD EN FIBRA DE VIDRIO

Vitro Fibras del Sureste, S.A. de C.V. A Division of Copiisa Offshore, S.A. de C.V.

ACCEPTANCE TEST REPORT (REPORTE DE ACEPTACION DE PRUEBA)

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WORK ORDER ORDEN DE TRABAJO	CUSTOMER CLIENTE	DRAWING No. No. DIBUJO	REV. No.	REPORT No. REPORTE No.	DATE FECHA

EQUIPMENT EQUIPO O PARTE	FABRICATOR'S NAME NOMBRE DEL FABRICANTE	PROCEDURE No / Rev. No. No. PROCEDIMIENTO / Rev. No.	SOURCE METHOD METODO DE FUENTE	MATERIAL TYPE TIPO DE MATERIAL

RELAXATION OPERATION DATA (TABLE T-1121) DATO DE OPERACIÓN DE RELAJACION	METHOD OF FABRICATION METODO DE FABRICACION	TEST LIQUID EMPLOYED LIQUIDO PRUEBA EMPLEADO	TEST LIQUID TEMPERATURE TEMPERATURA DEL LIQUIDO

PREVIOUS HISTORY OF MAINTENANCE MANTENIMIENTO PREVIO	ACCEPTANCE CRITERIA CRITERIO DE ACEPTACION	INSPECTION SPECIFICATION ESPECIFICACION DE LA INSPECCION	HYDROSTATIC TEST PRESSURE PRESION DE PRUEBA HIDROSTATICA

PRESSURE GAUGE No./ No. MANOMETRO	CALIBRATION DUE / VENCIMIENTO DE CALIBRACION	RANGE / RANGO

AE EQUIPMENT

MANUFACTURER'S NAME NOMBRE DEL FABRICANTE	MODEL NUMBER NUMERO DEL MODELO	SENSOR TYPE TIPO DE SENSOR	SYSTEM GAIN GANANCIA DEL SISTEMA	CALIBRATION DUE VENCIMIENTO DE CAL.

SKETCH OF FABRICATOR'S DRAWING WITH DIMENSIONS AND SENSOR LOCATIONS
CROQUIS DE LOS DIBUJOS DEL FABRICANTE CON DIMENSIONES Y COLOCACION DE SENSORES

TEST SEQUENCE / SECUENCIA DE PRUEBA

LOAD RATE RANGO DE CARGA	TEST PRESSURE PRESION DE PRUEBA	HOLD TIMES TIEMPO DE SOSTENIMIENTO	HOLD LEVELS NIVELES DE SOSTENIMIENTO

COPIISA OFFSHORE VITRODISEÑOS. CREATIVIDAD EN FIBRA DE VIDRIO

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ACCEPTANCE TEST REPORT / REPORTE DE ACEPTACION DE LA PRUEBA

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REMARKS OF ANY UNUSUAL OBSERVATIONS DURING OR PRIOR TO THE TEST / *NOTAS DE CUALQUIER OBSERVACION INUSUAL DURANTE O ANTES LA PRUEBA*

EXAMINATION RESULTS:
RESULTADO DE LA EXAMINACION

ACCEPTED ☐ ACCEPTADO **REJECTED** ☐ RECHAZADO **NCR No.** _____

SKETCH OF FABRICATOR'S DRAWING SHOWGING THE LOCATION OF ANY ZONE NOT MEETING THE EVALUATION CRITERIA
CROQUIS DE LOS DIBUJOS DEL FABRICANTE MOSTRANDO LA UBICACIÓN DE CUALQUIER ZONA QUE NO CUMPLA LOS CRITERIOS DE EVALUACION

ACOUSTIC EMISSION DATA / FECHA DE PRUEBA HIDROSTATICA

A.E EVENTS ABOVE THRESHOLD VS TIME FOR ZONES OF INTEREST A. E. por encima del umbral Vs. Tiempo para zonas de interés	TOTAL COUNTS VS TIME Total de Conteos Vs. Tiempo	SIGNAL PROPAGATION LOSS Perdidas por propagación de la señal

EXAMINED BY EXAMINADO POR:	APPROVED BY / APROBADO POR		
NDE LEVEL II SNT-TC-1A END NIVEL II SNT-TC-1A	QUALITY ASSURANCE MANAGER GTE. DE ASEG.DE LA CALIDAD	AUTHORIZED INSPECTOR INSPECTOR AUTORIZADO	CUSTOMER CLIENTE

FORM No.2.4 Rev. 0 DATE: 09-03-13

Sentro Technologies USA, LLC

General Procedure for Acoustic Emission Examination

1. Scope

1.1. This procedure describes acoustic emission (AE) examination of structures.

1.2. The purpose of the AE examination is to detect, locate and characterize AE sources active in the examined structure.

1.3. When proper methods of data acquisition and analysis are developed, and criteria are elaborated, AE data measured can be used for identification and quantitative or qualitative assessment of flaw indications. AE data may also be used for detection and evaluation of structural issues and/or operational conditions that are or may affect structural integrity of the structure in the future.

1.4. This practice is applicable to metal, composite and concrete structures and pressure equipment.

1.5. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

Jess Gamho 11/01/16 QA Approved.

2. Referenced Documents

2.1. *ASTM Documents:*

E 569 Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation

E 650 Guide for Mounting Piezoelectric Acoustic Emission Sensors

E 750 Practice for Characterizing Acoustic Emission Instrumentation

E 976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response

E 1139 Standard Practice for Continuous Monitoring of Acoustic Emission from Metal Pressure Boundaries

E 1316 Terminology for Nondestructive Examinations

E 2374 Guide for Acoustic Emission System Performance Verification

2.2. Other Documents:

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification

ANSI/ASNT CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel

3. Terminology

3.1. *Definitions*—See ASTM E1316 for terminology related to this practice.

4. Summary of Practice

4.1. This practice describes the use of AE technology to detect, locate and characterize AE sources due to flaw accumulation and development and AE sources of mechanical origin in structures under controlled loading or during their operation.

4.2. The practice provides guidelines for:

4.2.1. Preparation for the examination.

4.2.2. Installation, verification and setup of AE system.

4.2.3. The AE examination procedure.

4.2.4. Data analysis and estimation of significance of detected AE sources with respect to structural integrity.

4.2.5. Preparation of examination report.

5. Basis of Application

5.1. The following items are subject to contractual agreement between the parties using or referencing this practice.

5.2. *Personnel Qualification*

5.2.1. If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally and internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT CP-189, SNT-TC-1A, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

6. Apparatus and system installation

AE apparatus typically used for AE examinations consist of sensors, preamplifiers, cables, AE signal processor and optional accessory electronic devices.

6.1. *Sensors*

6.1.1. Sensors should have necessary sensitivity in the frequency range required for the examination.

6.1.2. Only sensors with known and verified characteristics should be allowed for the examination.

6.1.3. In addition to minimum sensitivity levels, it is recommended to select sensors with the smallest possible deviation in their characteristics in order to increase repeatability of results in case of the need for sensor replacement.

6.1.4. Sensors should be capable of operating under harsh environmental conditions. Special attention should be made with regard to temperature, dust, vibration and water to protect the sensors.

6.2. *Sensor mounting*

6.2.1. Sensors can be mounted using guidelines provided in E 650. Different adhesives and/or attachment mechanics can be used to hold sensors on the structure. In case of mechanical attachment, it is recommended to apply a constant, controllable load on sensors against the structure surface.

6.2.2. A coupling material suitable for environmental conditions of the plant should be used to provide an optimal sound transmission from waveguide to sensor surface. It is recommended to select a couplant so the drying out and degradation of the couplant over time due to extreme environmental conditions (heat and cold) will be minimized. The thinnest possible layer of couplant is recommended. Different types of adhesives and greases may be used as a couplant material.

6.3. *Sensors positioning*

6.3.1. In order to define sensor positions, it is necessary to receive from the plant isometric and detailed drawings of the structure with marked main structural elements and accessories.

6.3.2. Sensor position is determined by taking into consideration dimensions and the geometry of the examined piping.

6.3.3. Distance between sensors is governed by attenuation of AE waves along the structure. It is recommended that the maximum distance between sensors would not exceed 40 dB attenuation. Without undermining the above, the recommended maximum distance can be modified if attenuation analysis of AE waves characteristic to those potentially generated by target flaws is performed for the specific structure geometry and specific background noise/operational conditions. In zones with elevated background noise, the

distance between sensors can be shortened to allow better detectability. However, the primary objective of the examination is detection and detectability and that shall not be compromised even at the cost of linear location accuracy reduction.

6.4. *Preamplifiers*

6.4.1. The preamplifier converts the high impedance signal from the sensor to a low impedance signal and amplifies it to allow transmission over a long power cable.

6.4.2. The preamplifier should have a filter with a bandwidth appropriate for the examination.

6.4.3. The output impedance of the preamplifier should match the input impedance of the signal processing unit, typically 50 ohms.

6.4.4. Preamplifiers should be shielded from electromagnetic interference.

6.4.5. Preamplifiers' gain should be selected based on the background noise characteristics and required dynamic range.

6.4.6. Preamplifiers may have automatic-sensor-test (AST) functionality to allow testing of a sensor or set of sensors using artificially generated signals.

6.4.7. The preamplifier can be integrated into the sensor (integral sensor) or be in a separate case. In the last case, the length of the cable between a sensor and preamplifier should not exceed 1 m [3.3 ft.], must be shielded and have properly installed connectors.

6.5. *Power-signal cable* - The cable and connectors that provide power to preamplifiers and route the pre-amplified signals to the main processor shall be shielded against electromagnetic interference. The typical standard coaxial cabling used in AE examinations is RG-58 at 50 ohm impedance. The maximum recommended length of the cable is 300 m [1,000 ft] to avoid excessive signal attenuation. High temperature protected cables are recommended for use in a power plant environment. Cables should be properly mounted and fixed in cable

trays in case of permanent installations or to the structure and railing during temporary installations. Cables should not be over-tensioned and it is necessary to leave some slack within every piping section to avoid damage to cables, waveguides or sensors in the case of piping movement/displacement, especially when unit turned on or off. Contact of cables with hot objects should be avoided.

6.6. The main AE signal processor is a multichannel data acquisition system used to detect, process AE signals, calculate their parameters and store AE data. In addition, it can be used to measure relevant operational data such as pressure, temperature and etc. Each channel in the system should have analog and/or digital filters for filtering out unwanted frequency content of incoming signals.

6.7. The general characteristics of sensor-preamplifier-main AE signal processor chain with all analog and/or digital filters and gains should be known and be appropriate for the examination purposes.

6.8. Different accessory electronic devices, signal and noise generators can be used before and/or after the examination to verify system performance and track changes in the sensors sensitivity.

7. System Performance Verification

7.1. System performance verification should be conducted immediately before the examination. The goal of this is to ensure that the system is satisfactory prepared for the examination. Particularly it is verified that:

7.1.1. Sensors are properly mounted on the waveguides and maintain required sensitivity level

7.1.2. There are no short circuits in power cables

7.1.3. There are no other conditions that reduce sensitivity and reliability of the system

7.2. During and right after the examination it is necessary to verify that there is no change in system performance.

7.3. System channels which are found to have performance below required minimum should be repaired or replaced. Any significant change in performance during examination should be documented.

7.4. System performance verification can be performed by guidelines given in E 2374.

8. AE examination

8.1. An optimal examination procedure is considered one that ensures the maximum probability of flaw/fault indication detection while minimizing false negative findings. This can be achieved by the application of appropriate loading conditions, suitable equipment and methods of data acquisition and data analysis.

8.2. *Operational conditions for conducting AE examination.*

8.2.1. Optimal conditions for performing an examination are considered those under which flaws/faults naturally originate and develop in the examined piping. Therefore, AE examination should be conducted under full normal operational load and stress conditions of the structure or under stress conditions simulating those in operation.

8.3. *Duration of examination.*

8.3.1. Duration of examination under controlled load is defined by loading procedure.

8.3.2. Duration of the examination of a structure in operation is governed by the probability of flaw/fault detection. The probability of flaw detection depends upon the failure mechanism, examination setup, hit detection techniques, background noise characteristics, stress conditions and other factors. Duration of examination should be such that at least 6 signals related to the least active flaw indication to be revealed will be detected under specific AE

background noise conditions using the particular system and examination setup. Thus, for example, in zones with elevated background noise and/or with high thresholds, longer examination times may be required.

8.3.3. In any case, duration of the examination during structure operation should not be shorter than 30 minutes. Any deviation of this minimum requirement should be documented.

8.3.4. Examination duration should be increased to achieve consistent and statistically valid results in case of significant changes in operational conditions and/or elevated/varying AE background noise conditions due to any reason.

8.4. *Noise management.*

8.4.1. Strong and variable AE background noise can be one of the main challenges of AE examination. In certain cases minor changes in structure/system operation can significantly reduce AE background noise. Possible approaches for reducing background noise can be discussed with the plant operator and implemented whenever is acceptable and practical. Other means to manage noise effects on the examination performance is by selection of optimal equipment, system setup and methods of data acquisition and data analysis.

8.5. *System setup.*

8.5.1. *Hit detection techniques.* Detection of AE activity suspected to be flaw/fault development is a problem of statistical outlier detection. Different hit detection techniques, threshold dependent for burst AE signals or threshold independent for continuous AE signals and their combination may be used for examination. Among threshold dependent techniques, several floating threshold methods are often used for detection of AE burst signals. In order to minimize false positive hit detection by a floating threshold, or

additional parametric hit filtration is required. Normally hits with too short or too long duration, long rise times and few counts are eliminated.

8.5.2. *Frequency range* – the frequency range for conducting AE examination is typically between 50 kHz to 400 kHz. In case of elevated background noise or some noise disturbances due to friction or other reasons high pass filter can be set to 100, 200 or even 300 kHz frequency. Nevertheless, this may require shortening the distance between sensors due to increased attenuation. Also, any increase in the high pass frequency should be followed by analysis of attenuation and detectability of AE waves, characteristic to those generated by flaws to be revealed in the examined structure under specific background conditions and given sensor spacing.

8.6. *Operational data* – load, pressure, temperature, and other relevant operational data can be measured during examination or provided by the plant operator. This data can be used to analyze for possible correlation between AE activity and operational conditions.

8.7. *Documentation of sensors installation and of the structure* should be performed during examination and include information about exact position of the sensors on the examined structure.

8.8. *Visual survey* of the piping and its accessories should be conducted during examination for any unusual conditions or possible deficiencies. Visual surveys may provide important direct and/or indirect information about structure condition, possible overstressed zones, assist in interpretation of some of recorded AE activity, etc. All abnormal findings should be reported to the plant and documented in the report.

8.9. *Preliminary analysis* of the measured data must be performed in the field in order to reveal or rule out any severe conditions that may threaten safety of the examined structure and should be immediately addressed. Although such

scenarios are rare, still they happen and therefore the role of preliminary analysis cannot be under evaluated.

9. Data analysis

9.1. *Location* – different methods are applied for evaluation of AE source location. Commonly applied methods are time-difference linear location for burst AE signals, zone location, and energy attenuation based linear location for continuous and burst AE signals. In the case of energy attenuation based location, noise normalization should be performed to reduce location error due to difference of background noise conditions at different sensors.

9.2. *Location clustering* can be performed to identify AE source characteristics including likely AE origin, number of emissions vs. time vs. physical location, etc. AE activity locations should be compared with the position on the structure and findings of visual survey.

9.3. *Location accuracy and its reliability* can be limited in cases of strong and/or variable background noise and/or complex geometry. Due to these reasons, several location artifacts including and location scattering may be observed. It is important to note that all AE activity regardless if it is locatable or not should be analyzed, documented and reported.

9.4. *Flaw-indication identification and assessment.* One of the ideal goals of any Acoustic Emission examination procedure is flaw identification and assessment. At the current moment, this goal is not always achievable. However, at least in several cases when proper methods of data analysis and criteria are developed, AE data can be used for flaw-indication identification and assessment. Acoustic emission is flaw/fault-stage-material specific, i.e. different flaws and faults at different stages of their development in different materials have different AE characteristics. Therefore, flaw/fault identification (typification) and assessment

is possible, principally only when unique AE characteristics characterizing different flaws/faults indications at different stages of their development in the specific structure material can be identified, effectively distinguished and compared with similar characteristics obtained in similar applications and/or in laboratory tests with known flaws/faults at known stages. Features used in data analysis should have an established relationship with physical phenomena being measured during AE examination in order insure correct assessment of the examined piping. Signal parameters used for assessment of indications should be a minimum set of statistically significant features; filtered and normalized whenever is required so influence of background noise is minimized and data measured at different times and different locations is comparable.

9.5. *AE location vs. time vs. operational conditions* (temperature, pressure, etc.) *analysis.* Comparison of loading and operational conditions with AE activity and/or AE data parameters can be used to identify conditions causing flaw/fault accumulation, development, acceleration or arrest.

9.6. *Managing uncertainties.* During data analysis a conservative approach should be taken in case of uncertain results. Flaw/fault indications that can be equally classified into two different groups by their severity level should be attributed to the group corresponding to more severe flaws/faults. Also, all AE activity distinguishable from AE background noise should be considered as flaw/fault related activity unless proven different.

10. Report

10.1. Examination report should include the following information:

10.1.1. History of the structure, findings of previous AE examinations or of other NDE methods, repairs and maintenance.

10.1.2. Location of flaw suspected indications, their type and significance.

10.1.3. Drawings and/or table with examination findings.

10.1.4. Operational conditions under which these flaw-indications are most actively developing.

10.1.5. Findings of the visual survey.

10.1.6. Zones with reduced detectability and/or reliability of examination.

10.1.7. Conclusions and recommendations regarding the interval for the next examination and application of other NDE methods if necessary and where.

10.2. Re-examination of structure is performed to follow up on the condition of a structure over time. For success of monitoring it is necessary to identify quantitative and/or qualitative AE characteristics that are changing with flaw/fault development. It is important to perform monitoring at least partially under similar operational/stress conditions as during the previous examination. If a significant change in stress/operational conditions occurs for any reason, it may require change in the monitoring policy and re-inspection interval. In cases when structure is subjected to extreme dynamic event/s and trauma, it should be re-examined immediately after this event occurrence. Optimal re-inspection interval is such that a risk of unexpected failure is reduced to the minimum acceptable probability, defined for the specific structure with specific operational and stress conditions, weld configurations and specific flaw mechanisms. Presence of different risk factors should also be taken into consideration. Re-inspection interval can be shortened in case of reduced detectability or reliability of the examination due to high or fluctuating background noise conditions.

Vitro Fibras del Sureste, S.A. de C.V.
A Division of Copiisa Offshore, S.A. de C.V.

AE / Examiner Certification of Competency

Acoustic Emission Procedure Number: ID – QP – 003_R00

Technique: General procedure for Acoustic Emission Examination.

Reference: ASME Section X- RT-6, Section V- Article 11 and General procedure for Acoustic Emission Examination, (ID – QP – 003),R00.

AE Examiner: Eng. Eran Ben Tovim

I hereby certify that Eran Ben Tovim has demonstrated that he is qualified in the technique of the above listed Acoustic Emission Procedure, including making the examination and interpreting and evaluating the results.

Date: 01/11/18

TITLE: Quality Assurance Manager

Recertification: This individual has performed a AE examination on the following dates and is thereby recertified for the period of one year.

Date of examination	Recertification due	Date of examination	Recertification due
01/28/2014			