ABSA the pressure equipment safety authority

GUIDELINES FOR THE INSPECTION

OF

INSTALLED FIRED HEATERS

AB-507

FORWARD

These guidelines are intended to provide advice and recommendations for in-service evaluation of fired heaters installed in Alberta. They were originally developed in 1992 by members listed below and have recently been updated based on input from Alberta Refinery and Petroleum Chief Inspectors Association (ARPIA) members and have recently been revised to incorporate input from the Alberta Refinery & Petrochemical Chief Inspectors Association and others.

ORIGINAL COMMITTEE MEMBERS

<u>FIRED HEATER TASK GROUP MEMBERS</u>

Doug Fawcett
Petro Canada Products
Edmonton Refinery

Ian Forrest
Sherritt Gordon Ltd.
Fort Saskatchewan, AB

Dennis Horne
Celanese Canada Inc.
Edmonton, AB

Bernie Hurst
ABSA
Edmonton, AB

Murray Jamieson
Esso Strathcona Refinery
Edmonton Refinery

Bruce McWhirter
ABSA
Edmonton, AB

Ed Parans
Suncor Inc.
Fort McMurray, AB

Peter Staneland
Canadian Turbo Inc.
Balzac, AB

Stephanie Sterling
Shell Canada Products Ltd.
Fort Saskatchewan, AB

Blake Switzer
Novacor
Red Deer, AB

Keith Vienot
Syncrude Canada Ltd.
Ft. McMurray, AB

ABSA wishes to express their appreciation for efforts put in by the committee and others and fully supports these guidelines to enable ABSA to work in partnership with Industry to promote pressure equipment safety.

ABSA supports the use of these guidelines as a means to improve industrial safety. However, neither ABSA nor any of the contributors can accept any liability for any damage or alleged damage resulting from the use of these guidelines.

Please contact Mike Poehlmann (poehlmann@absa.ca) if you have any questions or suggestions to improve this document.

FIRED HEATER GUIDELINES

TABLE OF CONTENTS

GUIDELINES FOR THE INSPECTION OF INSTALLED FIRED HEATERS

1. GENERAL

1.1 PURPOSE & SCOPE

This document presents a technical overview and information concerning inspection assessment, repair and replacement of installed fired heaters components. Although it is recognized that fired heaters in Alberta generally have a good safety record, there have been several failures and in some instances there may be a basis for concern especially in light of the trend to extend the life of pressure equipment.

These guidelines were prepared from the collective experience of a number of major chemical and petroleum organizations. They are intended to assist owners in ensuring that inspection and repair programs are in place. Such programs are necessary for the safe and economic operation of fired heaters, and for owners to meet Alberta regulatory requirements.

The scope is limited to installed fired heater pressure coils in any mixture of hydrocarbon service, including: return bends; fittings; manifolds, radiant and convection coils, internal and external crossover piping, headers, pigtails and all associated welds.

The American Petroleum Institute has issued a Recommended Practice 573, containing detailed requirements on the inspection of fired heaters, which should be used to supplement these guidelines.

The relevant sections of the Alberta Safety Codes Act and Regulations should be carefully reviewed as these take precedence over all referenced publications.

1.2 REFERENCED PUBLICATIONS

Latest Accepted Edition of the following:

API RP 573- Inspection of Boilers and Fired Heaters Recommended Practice

National Board Inspection Code ANSI/NB-23-Manual for Pressure Vessel Inspectors

API RP 530 Recommended Practice for the Calculation of Heater Tubes in Petroleum Refineries

B51 CSA Boilers and Pressure Vessel and Piping Code

1.3 DEFINITIONS

Tubes in these guidelines shall also mean return bends and other fittings.

Alberta Act - Alberta Safety Codes Act and Regulations as they apply to pressure equipment.

Authorized Inspector- Designated ABSA Inspector.

ABSA – the pressure equipment safety authority.

2. ONLINE EVALUATION

2.1 VISUAL OBSERVATIONS

Online visual inspection of visible flame patterns can indicate potential areas of concern. An erratic, unbalanced flame may be a sign of damaged swirl vanes, improper air/fuel mixture, coking on the burner tip or leaking tubes. An erratic flame may impinge on nearby tube walls, causing hot spots and areas of potential ruptures.

Structural components, such as tube supports, that are visible from inspection ports should be examined to ensure they are intact. Any external tube suspension systems and pre-load and compensating devices should also be subject to routine inspection.

Tubes should be inspected for bulges, sagging, bowing, localized discolouration or leakage. Hot spots may be the result of flame impingement. Tube misalignment may be caused by damaged supports, or supports that are preventing the thermal growth of the tube.

Refractory should be visually checked for cracking, spalling, erosion, and localized discolouration. Areas of damage should be monitored for high temperatures and identified for repair during the next planned outage.

A visual examination of the external casing should be made to detect any hot spots.

2.2 TUBE TEMPERATURE MONITORING

Tube failures are most commonly due to overheating. Therefore close attention must be paid to on-stream monitoring of tube temperatures.

There are two basic systems for tube temperature monitoring:

1) Contact - tubeskin thermocouple
2) Non-contact pyrometers

2.2.1 CONTACT PYROMETERS

There are several types of tubeskin thermocouples in use. These are typically welded to the tubes in strategic locations. Proper placement and coverage with skin thermocouples enables them to be viewed through the observation ports for calibration of the non-contact pyrometers. Tube skin thermocouples are applied to the areas of highest heat input and tube metal temperatures. The number and placement required depends on the furnace design. Normally the hottest area is at one-third firebox height. Attention should also be paid to the first rows of finned tubes (shock/shield tubes) in convection sections as it has been found that this is the hottest area in some furnaces.

2.2.2 NON-CONTACT PYROMETERS

Optical and infrared style pyrometers can be used to scan fired heaters to determine if areas of local overheating exist. As the firing, oxidation scaling of the tubes, surface finish, etc. can effect the accuracy of the readings; it is strongly recommended that a calibration target plate be utilized (skin thermocouple attached).

Routine recording of tube temperatures into a permanent record is crucial to enable the remaining safe life of the tubing and suitable inspection intervals to be established.

The size and/or location of inspection openings on some existing furnaces do not permit meaningful results to be obtained. In these instances, consideration should be given to installing additional larger openings. This should also be identified when replacement equipment is ordered.

2.3 CHARGE STOCK CHARACTERISTICS & OPERATING DATA

For both new and existing furnace assemblies, a periodic review of the process fluid characteristics should be undertaken and include the following:

1) Corrosivity (Sulphur, Sediment, Water Content, Acid Neutralization Number, etc.)
2) Fouling/Coking Characteristics
3) Variance to the Original Design Values, (i.e.: Hydrogen to Naphtha Ratio, API Gravity, Boiling Point, Feed Rate)

Suitable operating data should also be maintained such as: approximate run times, any outages, pressure drop through heaters, stack temperatures, tube temperatures, changes in decoke or other cleaning procedures.

Process fluid characteristics and operating data should be evaluated weekly by inspection staff to identify any conditions that could affect the inspection requirements and inspection intervals.

3. OFFLINE INSPECTION

3.1 VISUAL OBSERVATIONS

The tube coils should be inspected closely for bulging, bowing, sagging, splitting, scaling, corrosion, and deposits from fuel gas. Fittings may show signs of damage, distortion or corrosion. Internal inspection of tubes is limited to those types which have removable U-bend or plug type fittings. Remote examination may also be utilized, using a boroscope, video camera or other visual aids. Suitable record such as videotapes should be maintained.

1) **Boroscope (fibrescope)**
   This is a flexible fibre optic instrument that is inserted into a tube through an opening, such as a thermocouple or pressure tap. It enables an internal visual inspection of the tube to be made up to distances of approximately 8 feet.

2) **Video Cameras**
   Cameras are becoming smaller and may provide some access for internal tube inspections. Some high resolution equipment has a working length of up to 70 feet.

When tubes are subjected to excessive temperatures they may sag or bow. This, on its own, is not usually indicative of creep damage; or high temperature metallurgical changes such as decarburization or graphitization etc. However, it may cause physical distortion or excessive stress on return bends, or leakage of rolled joints in tube sheets etc. Limits should be set on the deviation from the centre line where bowing occurs. (i.e. one tube dia.)

In the Convection section, sagged or bowed tubes that nest together and prevent circulation of the flue gas around the tubes, may cause overheating of adjacent tubes and draft loss. When this occurs the distorted tubes may have to be replaced.

3.2 THICKNESS MEASUREMENTS AND RECORDS

Ultrasonic thickness readings should be taken at specified locations on tube coils in the radiant section, accessible shock (shield) tubes in the convection sections and return bends.

Recent technological advances in furnace tube inspection has seen the development of a multi-module pig which can increase the number of data points from the typical 200-300 to in excess of 300,000. The tool can be used to inspect both the convection and radiant sections. However, since it uses ultrasonics, the inside of the tubes must be cleaned prior to inspection.

Suitable records of the readings and minimum required design thicknesses must be kept to enable the remaining service life of the components to be predicted. Typical inspection records and reports are contained in Section 7 and Section 9.

3.3 TUBE GROWTH MEASUREMENTS (CREEP RANGE)

Tube coils and return bends should be gauged for bulging or creep growth and the history of tubes that have been replaced due to thermal growth should be kept.

Thermal growth may occur when the tubes are subjected to localized short-term overheating, long-term high temperature exposure (creep), or localized thinning of the tube through corrosion or erosion.

The maximum limits of diametrical growth based on acceptable levels of creep must be established and readings checked against these limits. Special pre-set gauges can be used to quickly scan the length of a tube and a micrometer used to take precise measurements at pre-selected locations or areas of concern.

The multi-module pig tool mentioned in Section 3.2 also uses laser triangulation to determine the inside diameter of the tubes which can be used in looking for potential creep damage.

3.4 CHLORINATION & CARBURIZATION ASSESSMENT

Chlorination - is the corrosion by chlorine of a high grade alloy, the surface of which has been dispossessed partly or wholly of its protective chromium oxide Cr_20_3 layer. Following the chlorine corrosion and the destruction of the Cr_20_3 layer, chlorination becomes intense and causes a spongious metal. Chlorination proceeds by gaseous iron and chromium chlorides formation and the remaining alloys become porous and enriched in nickel.

Carburization - is the diffusion of elemental carbon into solid steel in contact with a carboniferous material at high temperature. This results in a brittle material.

3.4.1 INSPECTION

Chlorination and carburization affects the magnetic properties of the tube material.

An eddy current instrument (hall effect hand held probe) called a magnetoscope (Forester, Germany) should be used to build up a history of magnetoscope measurements. Any tube that indicates higher magnetoscope readings in any region should be checked by dye penetrant on the O.D. for cracking. Radiography should be carried out on the region to determine the condition of the I.D.

3.5 RADIOGRAPHY

Radiography may be used to inspect weldments, tubes, and return bends etc. It will provide evidence of wall thinning, deposits, pitting, cracking and internal obstructions etc. In circular heaters the film can be placed behind each set of tubes or return bends at a given elevation, and the source can be located in the centre. One panoramic exposure can then be taken that includes all of the tubes.

When radiographing a tube to determine if corrosion, deposits or coke is present, it is important to remember that these will usually occur on the fire side of the tube, as this is the hottest side of the tube. If a radiograph is taken on a horizontal tube, the film should be placed as close to the horizontal plane as is practical. The resulting film will show the profile of the fire side of the tube wall and the opposite side furthest from the source of heat.

3.6 HAMMER TEST

A hammer test is an accepted method of locating areas of reduced thickness in certain materials. However, it should be noted that some materials such as cast tubes, chromium alloy tubes, and those subject to carburization, should not be hammer tested.
Details regarding hammer testing are contained in API RP 573 Section 5-4.5 Page 32.

3.7 HARDNESS MEASUREMENTS

Hardness Testers - mechanical and electronic hardness testers can be used to determine the hardness of base metal, welds, and heat-affected zones. Electronic testers must be used with extreme care on thin materials or erroneous readings may be obtained. Hardness tests should only be specified only after it has been determined that the base material is suitable; as some materials (i.e. carburized, cast materials) may well be damaged if hardness readings are taken.

3.8 NON-DESTRUCTIVE METALLURGICAL TESTS

Nuclear Analyzers - are used to confirm the nominal metallurgical composition of materials.

In site Metallography- provides metallurgical information to check for material deterioration, creep damage etc.

3.9 SCALE AND DEPOSIT ANALYSIS - INTERNAL AND EXTERNAL

Scale/Deposits- Samples of surface scale and deposits can be analyzed to determine composition, source of contamination and provide an indication of the degree of overheating.

3.10 REMOVAL OF TUBES AND FITTINGS FOR METALLURGICAL ANALYSIS AND MECHANICAL TESTING

It may be necessary to remove samples to assess the mechanical and metallurgical integrity of furnace components that are approaching their design life and cannot be assessed in place due to the design (i.e. finned tubes), or when inspection results indicate that sample removal is required to enable the overall condition of the furnace to be verified.

Metallurgical considerations for sample removal would include: suspected high temperature creep damage, sensitization, carburization, decarburization, spherodization, oxidation, embrittlement, etc.

A plan should be developed for tube removal and include:

1) Need to implement specific neutralization procedures (material dependent).

2) Tube material availability for replacement.

3) Review of welding requirements, including the weld procedure and qualifications of welder.

4) Non-destructive testing requirements, such as radiography, liquid penetrant and magnetic particle examination.

5) Post weld heat treatment requirements and schedule.

6) Hydrostatic test procedure and schedule.

7) Need to dry furnace after hydrotest.

3.10.1 CRITERIA FOR REMOVAL

Consideration should be given to removing tubes for remaining life evaluation when any of the following conditions are met:

1) Service life has reached design life. A typical design life value is 100,000 hours. However, the actual life may differ considerably from the design life, when the operating conditions vary from the design specifications.

2) Creep damage has been detected from tube measurements.

3) Metallurgical deterioration is suspected due to the operating and service conditions.

4) Tube failures or leaks have occurred in the furnace.

5) Unusual operating conditions or upsets may have caused localized or high rate deterioration.

Sample mechanical testing and metallurgical analysis requirements for remaining life assessment should be established prior to sample removal. Some organizations have found the following to be suitable for sample removal:

1) One sample from a radiant coil, one from a convection shock tube, and one sample tube from a convection finned section be taken. Removal of a section of least 24" long is recommended.

2) Samples should represent the maximum tubeskin exposure temperatures experienced in the firebox. Generally this would occur at one-third to two-thirds of the firebox height. The convection section requires particular attention, especially if tubes are finned. Flame patterns, tubeskin temperatures, and visual observation will determine the appropriate tube section to be removed. When applicable, simulated tube metal temperatures should be obtained for all radiant and convection tubes to determine the most severe condition. This is not practical for certain designs.

3) The fire or hot side of the tube surface, and furnace cold wall should be identified on each sample prior to removal and its orientation and position noted.

3.10.2 EVALUATION

This section outlines recommended minimum requirements for sample removal and evaluation:

One longitudinal tensile specimen should be removed from both the hot and cold side of the furnace tube section. The yield point, ultimate tensile strength and the percentage elongation shall be recorded.

Samples should be removed from both sides of the remaining tube sections for metallurgical analysis of the microstructure.

The following data should be documented for each furnace tube tested:

1) Process

2) Current Service Life - including furnace tube outside diameter composition and number of hours of service.

3) Temperatures and Pressures - operating and design.

4) Skin Temperatures Alarms - as per API RP-530.

5) Actual Monthly Average Recorded Skin Temperatures.

3) Tube Thickness Data - including original, retirement and present maximum and minimum values.

4) Mechanical Properties - including design and actual values based on tensile test results. Record date of sample, yield, stress ultimate, tensible stress, percentage elongation and hardness values.

5) Creep Growth - include maximum outside diameter permissible and the present maximum outside diameter. Pendant limits for increased length can be evaluated.

6) Inspection Data - major historical data such as tube removal location, flame impingement, temperature excursions and/or fires.

7) Metallurgical Results - interpretation of the general condition of the microstructure complete with a photomicrograph at 200x magnification detailing the etchant, Rockwell hardness and sample name and location. Samples of scale and deposits should be taken and analyzed when applicable.

8) If upset conditions are not documented, an estimate of these shall be determined.

3.11 PRESSURE TEST

Before the furnace is returned to operation, a pressure test on the tube coils will reveal any leakage not apparent from a visual inspection.

All pressure tests should be performed in accordance with a written procedure which includes the safety precautions to be taken, test pressure and temperature, how water will be drained from vertical coils etc. Refer to Section 5.5 for detailed pressure test requirements.

3.12 LIFE ASSESSMENT

A detailed evaluation of the remaining life of the furnace pressure components should be carried out when the furnace has reached 100,000 hours service or the design life if less; or as indicated from inspection data. (Refer to Appendix E - RP530 88 EDT). The results of this evaluation shall be documented in both the Engineering Equipment files and Inspection Historical records.

4. ACCESS FOR INSPECTION

The following information is provided to enable personnel to determine how access can be provided to enable the condition of the fired heaters to be evaluated.

4.1 TYPES

The available inspection methods that can be reasonably employed to inspect a heater are often limited by the access required. The amount of access is usually determined by the urgency of the inspection as well as the time and resources available. The different degrees of access can be classed as basic, medium, and full access.

Basic: Entry to the furnace and base of the stack (top of convection bank) only. No ladders or scaffolding available. This permits a general visual inspection of the heater, and a detailed inspection of what can be reached.

Medium: Entry as above but with partial scaffolding or ladders available. This permits additional areas to be inspected.

Full: Entry as above but with total scaffolding to reach underside of convection bank and crossover tubes etc. The convection end covers are removed to access the convection return bends. Full access enables all radiant tubes and return bends to be inspected: Ultrasonic Testing, Radiographic Testing, Visual etc. External crossover piping can be accessed via scaffolding and insulation stripped locally to permit examination. It should be noted that on most furnaces full access is required to assess their continued reliability .

4.2 CONVECTION TUBES

The access described above does not fully address concerns involving access to finned convection tubes that are deep within the bank.

Usually the most severe fouling using various feeds occurs in the convection section. Solids may precipitate here due to fluid flow changes and phase changes, especially when the feed initial temperature is high. Therefore, it is critical that the convection section be inspected especially if the tubes are thinned or the feedstock quality is unknown. (Note liquid/vapour phase is often the location where the highest corrosion is likely to take place)

It should be noted that in some furnace designs, finned convection tubes above the shield tubes have been found to have the highest skin temperature, so assessment of bare shield tubes may not provide adequate basis for permitting continued operation of other tubes.

Given the limited access, there are a number of things that can be used to gain additional inspection information on these tubes, as follows:

1) Selected locations on the upper rows can be radiographed.

2) A boroscope may be placed among the tubes (externally) to assess the condition of the fins. This information could be used to justify pulling a tube for analysis. Refer to Tube Removal, Section 3.10.

3) If there are any pressure taps available it may be possible to insert a boroscope down inside a pressure tap tube to get a visual check for pitting, erosion, coking etc.

4) Return bends can be cut out to allow for an internal visual inspection and deposit analysis.

5) The installation of convection access doors on each side of the convection bank (recommended min. 2ft x 4ft) should be seriously considered. The placement of these doors would provide access to the inaccessible sections (middle) of the convection bank for visual and radiographic inspections.

6) Inspect condition of fins on convection tubes. The maximum temperature area can be determined by observing the area of most severe fin oxidation. If the metallurgy of the fins is known, it may be possible to approximate temperatures based on the condition of the fins.

5. REPAIR AND ALTERATION METHODS

5.1 GENERAL

When a proposed repair or alteration to the pressure envelope of a fired heater is not in accordance with the original design (i.e. where the material has been changed) the proposed repair or alteration shall be submitted for acceptance to ABSA Design Survey.

All repairs and alterations shall conform, in so far as possible, to the latest applicable construction code. Information contained in API RP573 Section 9, and CSA B51 Paragraph 10 and 11 and Appendices B & F should also be considered when developing repair and alteration procedures. The regional ABSA inspector is to be informed prior to commencing any repairs or alterations. Note some exceptions to the requirement for an ABSA inspector may apply under an owner/user certification.

5.2 WELDED REPAIRS OR ALTERATIONS

All welding shall be performed in accordance with welding procedures qualified to ASME Section IX and the referencing Code. It should be noted that such procedures may not adequately address all the pertinent service requirements, such as creep resistance, hydrogen damage resistance, etc.

Welders shall be qualified in accordance with ASME Section IX and hold valid performance qualification cards for the procedures to be used.

Any microstructural changes, material contamination, neutralization requirements shall also be evaluated when designing the repair method to be used. Some neutralization standards are referenced in NACE i.e. Standard RP-01-70.

When designing repairs to bimetallic welds and those that operate at high operating temperatures, consideration shall be given to material degradation due to carbon diffusion and material aging. Materials that are not normally preheated for welding (i.e. austenitic materials) may benefit by being preheated. Additional heat treatment such as solution annealing may also be necessary.

5.3 REPAIRS WITH LIMITED SERVICE

On occasion it may be necessary to perform repairs that meet acceptable standards but may not be suitable for extended service. These shall be identified and suitable procedures initiated to ensure that they are removed within the allocated safe interval.

5.4 MECHANICAL REPAIRS OR ALTERATIONS

Mechanical repairs are any type of repairs that do not require welding. These include clamped types of enclosures, pigtail pinching, tube straightening, etc. These repairs may be made while the equipment is operating (online) or when it is shutdown. ABSA acceptance is required.

All repairs to operating equipment shall be conducted in accordance with established general procedures and to specific plans.

5.5 PRESSURE TEST

A full temperature compensated hydrostatic test in accordance with ASME B31 345.1. is required when welded repairs to the pressure envelope have been made. (Note the test pressure may be limited by other components in the system such as flanges and crossovers). When a full hydrostatic test is not practical, a pneumatic test or alternative testing may be conducted in accordance with ASME B31.3 345.5 to 345.9. The use of pneumatic or alternative test procedures requires prior acceptance from ABSA.

For minor repairs, as defined in the Owner/Users Approved Quality Control Manual, and accepted by ABSA, these tests may be waived and additional nondestructive testing substituted.

6. JURISDICTION REQUIREMENTS

6.1 FIRED HEATERS

Fired heaters installed in Alberta that contain an expansible fluid are under the jurisdiction of the Alberta Safety Codes Act and subject to requirements listed below:

1) New heater designs must be registered separately in accordance with Part 2, Section 6 of Alberta Design and Construction Regulations.
   Note - Some earlier designs were registered collectively with the plant piping.

2) Requirements contained in B51 Appendix F are mandatory in Alberta for new designs and welded replacement parts, and repairs.

3) An Organization constructing, repairing, or altering a fired heater must have a valid Alberta Quality Program Certification of Authorization for the scope of work.

4) New construction and welded replacement parts shall be documented on a Fired Heater Data Report (Exhibit No. 6). This report shall be certified by the manufacturer and an independent Inspector acceptable to ABSA. (ABSA Inspector when work is done in Alberta).

5) Heaters are subject to initial inspection by an ABSA Inspector who will assign an Alberta "A" number to each unit.

6) Heaters are not currently subject to annual registration or annual inspection by ABSA unless the unit contains a steam generating section.

7) Repair and alteration procedures shall be accepted by the ABSA Inspector prior to the start of work. Submission of alteration procedures and pneumatic and alternative test procedures to ABSA for registration is required unless specifically exempt by the ABSA. See Note #1 below.

8) Repairs and alterations are subject to inspection by the ABSA Inspector. See Note #1 below.

9) Repairs and alterations shall be documented using ABSA Form AB-40.

   Note #1 - This requirement may be waived for routine repairs as defined in the owners approved Quality Control Manual and accepted by ABSA.

7. REPORTS AND RECORDS

7.1 GENERAL

Typical sample records that are kept are shown in this section.
Typical reports are provided in Section 9, Exhibits.

The existence and continuous update of complete records are paramount in evaluating the safe remaining life and optimum inspection intervals. Suitable documentation also provides the basis for establishing schedules of repairs, replacement parts, inspection and tests, sample removal, etc.

It is important that datum readings are taken before equipment is placed in initial operation so that any changes in thickness, diameter, etc. can be accurately determined.

7.2 TYPICAL RECORDS KEPT

1) Mechanical Design Data (i.e. API Data Sheets)
2) Manufacturers Fired Heater Data Report(Exhibit No 6)
3) ASME Manufacturers Data Reports (for steam generating coils)
4) Material specifications
5) Drawings, general arrangement, etc.
6) Tube layout drawings showing the actual arrangement of tubes and fittings in the heater, flowsheets, thermocouple locations, etc.
7) Records of process conditions
8) Record of corrosion rates
9) Flowsheets
10) Continuous inspection history, tubes removed, recommendations and observations, etc.
11) Inspection Plan including:
    - examinations, inspections, tests, and sample tube removals etc. and intervals
    - applicable procedure reference numbers
    - on-stream inspections, temperature measurements etc.
    - inspection review of operating conditions

12) Detailed Inspection Reports including:

- visual inspection records, inspection findings etc. (refer to Section 9)
- thickness and gauging record of tubes and fittings including data readings prior to commissioning (refer to Section 9)
- radiographic and other NDE results
- pressure test records
- repair procedures and repair reports
- record of material replacement
- life extension reports
- other

8. DESIGN INFORMATION

8.1 DESIGN DATA

When purchasing or constructing a new heater assembly, the information requested in the API 560 Data Sheets shall be kept on file. Jurisdictional requirements are outlined in Section 6.

For existing furnaces where the API 560 data sheets may not exist, the appropriate design limitations for the pressure components shall be obtained and kept on file including:

- Design basis for tube wall thickness
- Design basis for rupture strength (minimum or average)
- Minimum design life
- Design pressure and maximum tube metal temperature
- Tube material composition
- Hydrotest pressure
- Inlet and Outlet process fluid pressures and temperatures

For operating furnaces, changes in the type of fuel must be evaluated with respect to issues identified above.

8.2 DESIGN ENHANCEMENTS

To enable the condition of convection sections to be assessed, some owners are installing additional removal panels in these sections. Design enhancements being considered for replacement furnaces include:

- requiring at least 70% of convection tubes to be accessible
- standard access opening to be at least 2' x 4' min.
- using removable return bends
- using only bare tubes in the design
- performing tube skin calculations and reducing quantity of finned tubes (i.e. four bottom convection rows bare tubes rather than only two)
- using studs instead of fins.

9. EXHIBITS (TYPICAL REPORTS)

9.1 TYPICAL REPORTS

1) Fired Heater Inspection Report Format — Exhibit #1
2) Fired Heater Inspection Checklist — Exhibit #2
3) Fired Heater Specification Sheet — Exhibit #3
4) Tube and Fitting Test Point Measurement Report — Exhibit #4
5) Coil and Fitting Orientation\Test Point Location Sketches — Exhibit #5 (a), (b), and (c)
6) Fired Heater Data Report — Exhibit #6

EXHIBIT NO. 1 **FIRED HEATER INSPECTION REPORT**

Report No.
Item No.
(A) Number

Plant ________________________ Next Inspection Date ________________

Item Description ________________________ Date of Inspection ________________

Type of Inspection ________________________ Last Inspection Date ________________

FIRED HEATER INSPECTION FORMAT

GENERAL SUMMARY

Initial condition of heater and reason for Inspection. Inspection Summary.

RADIANT TUBES

Condition of tubes as to bowing, growth, and wall thickness.

CONVECTION TUBES

Condition of tubes as to bowing and condition of fins and ultrasonic wall thickness measurements on shock tubes if accessible.

HANGERS AND SUPPORTS

Condition of all hangers and supports

REFRACTORY

Condition of refractory and lintels.

BURNERS

STACK AND DAMPERS

ROOF HANGERS

REPAIRS

RECOMMENDATIONS

________________________ ________________

Inspected by Date

cc:

EXHIBIT NO. 2

FIRED HEATER INSPECTION CHECKLIST - Page 1 of 3

To... **Certification Period...................................**
Plant.. **Report No..**

Item No.. **Name...**

Date of Inspection................................... **Type of Inspection...................................**
Date of Last Inspection.......................... **Alberta Reg. No.......................................**

FURNACE CHECKLIST

	FIRST	REMARKS/REPAIRS	FINAL
What's Open - Radiant Section			
- Convection Box			
SECTION 1 - RADIANT SECTION 1) Identified the tubes according to sketch. (Mark the tube numbers on the tubes.)			
2) Inspect for bowing and tubes bulging (flashlight against tubes)			
3) Flag lower U bends for Radiography a) Thickness Measurements			
b) Obstruction			
c) Bulging			
4) U.T. Measurements 6' Level			
9' Level			
18' Level			
Top U Bends			
5) O.D. Readings: Gauge entire tube, set gauge at: a) 1.5% growth			
1.0% growth			
5.0% growth			
b) O.D. Readings at: 6' Level			
9' Level			
18' Level			
6) Scaffolding Required at every 7 feet			

HEATER INSPECTION CHECKLIST - Page 2 of 3

	FIRST	REMARKS/REPAIRS	FINAL
7) Inspect Refractory			
8) Inspect Hangers and Supports			
9) Inspect Burners			
SECTION II - SHOCK TUBES 1) Mark Identification numbers on tubes			
2) U.T. Measurements			
3) O.D. Readings a) Entire tubes gauged			
1.5% growth			
3.0% growth			
5.0% growth			
b) O.D. Readings			
SECTION III - CONVECTION SECTION 1) Identified the tubes according to sketch. (Mark tube number on the tube)			
180° End			
0° End			
2) U.T. Measurements Tubes			
U-Bends			
3) O.D. Measurements			
4) Inspect Tubesheet			
5) Inspect Inside of Convection Box a) Tube Fins			
b) Refractory			
c) Damper			
d) Stack Internal (if accessible)			

HEATER INSPECTION CHECKLIST - Page 3 of 3

SECTION IV - EXTERNAL			
1) Inspect Stack (if applicable) a) Hammer Test			
b) U.T. Measurements			
c) Bolts Intact			
2) Inspect Shell a) Visual (Ripples and Warps)			
b) U.T. Measurements (if applicable)			
3) U.T. Measurements Inlet Piping			
Outlet Piping			

REMARKS

EXHIBIT NO. 3

FIRED HEATER SPECIFICATION SHEET

Heater Equipment No. and Description: ______________________________

Process Fluid: ______________________________

1. Convection Tubes (#1 and #2) A312-TP321
   Stainless 3.5” O.D. x 0.30” A.W. (Finned)
   Fins-Carbon Steel 0.75” High x 0.05” THK x 54 Per Ft.

2. Convection Tubes (#3 to #6)
   321 Stainless 3.5” O.D. x 0.30” A.W. (Finned)
   Fins 11% Chrome 0.75” High x 0.05” THK x 54 Per Ft.
   ASTM-A312-TP321

3. Convection Tubes (#7 to #10)
   321 Stainless 3.5” O.D. x 0.30” A.W.
   ASTM-A312-TP-321

4. Radiant Tubes (#11 to #24)
   321 Stainless 3.5” O.D. x 0.30” A.W.
   ASTM-A312-TP321

5. Convection and Radiant Return Bends
   Stainless to Fit 3.5” O.D. x 0.30” A.W.
   ASTM-A351-GR CF8C

6. Cross-Over Elbows
   Stainless Steel to Fit 3.5” O.D. x 0.30” A.W.
   ASTM-A351-GR CF8C

7. Cross-Over Piping
   321 Stainless 3.5" O.D. x 0.30” A.W.
   ASTM-A312-TP321

Design Pressure ....1650 PSIG
Design Fluid Temperature ....950° F
Inlet Temperature .... 950° F
Inlet Pressure PSIA ....1549 PSIA
Outlet Temperature .... 860° F
Max. Tube Wall Temperature .... 1050° F
Corrosion Allowance Tubes & Fittings ....0.100”
Hydrotest Pressure ....
Radiography...
PVS Heat Treatment ....
Year Built ....

EXHIBIT NO. 4

FIRED HEATER

TUBE TEST POINT MEASUREMENT REPORT

EQUIPMENT NO. AND DESCRIPTION ____

COIL NO. ______________________ SKETCH NO. ___________________

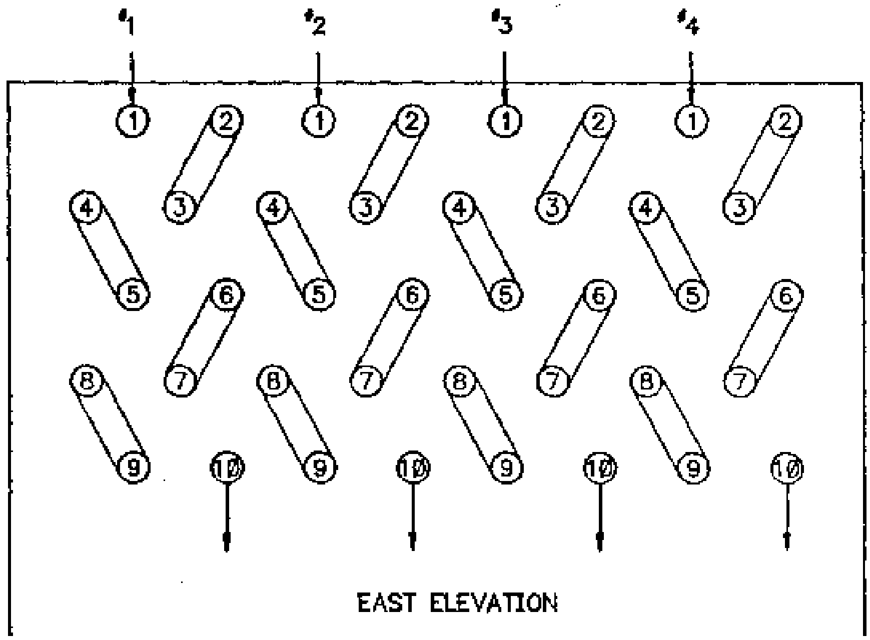
MATERIAL ____

Tube/ Fitt. Id No.	Test Point Desc.	Init. Date	Init. Value	Retir. Thick-ness	Test Date	Test Value	Test Date	Test Value	Test Date	Test Value	

EXHIBIT 5A, B, C

EXHIBIT. 5A ITEM No. ______

HEATER DESCRIPTION ______________________



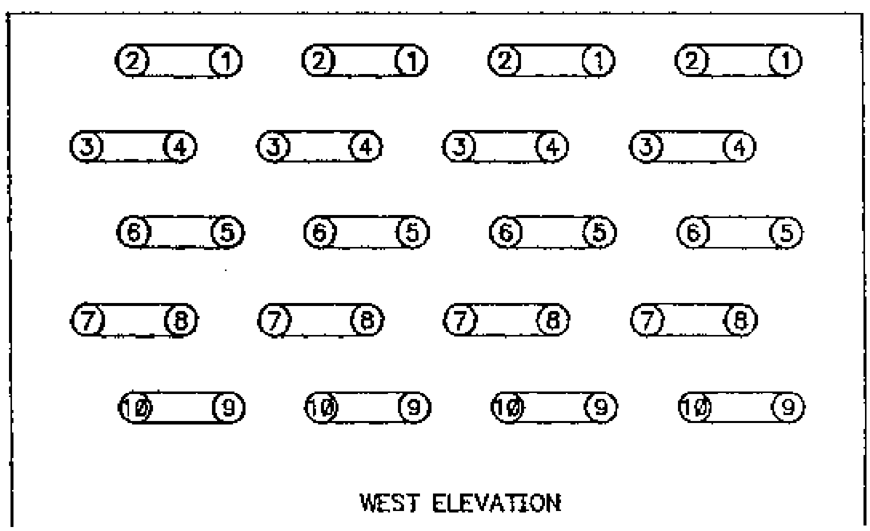
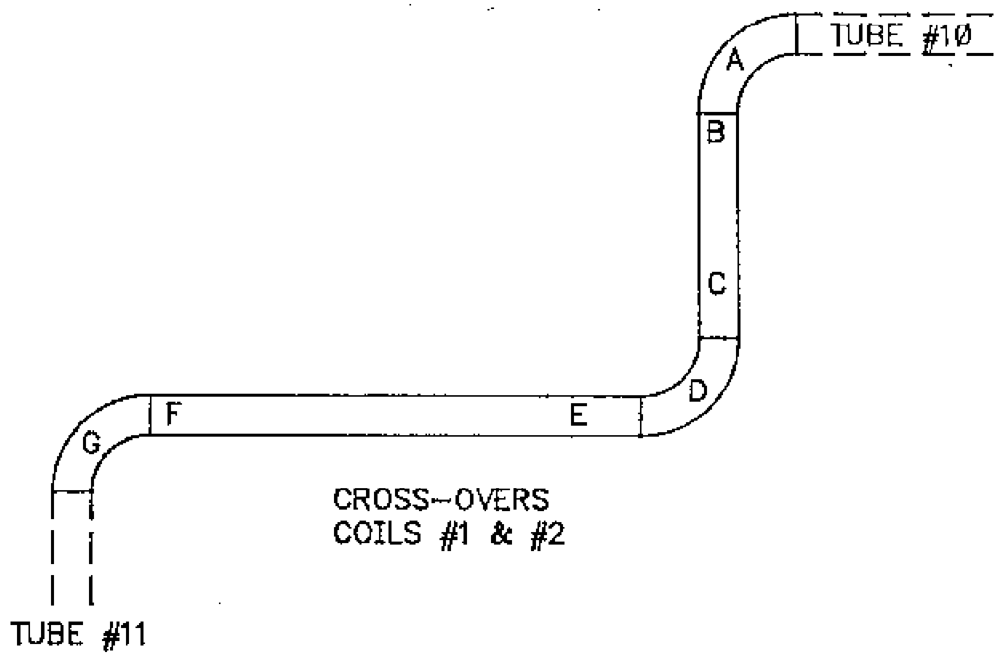


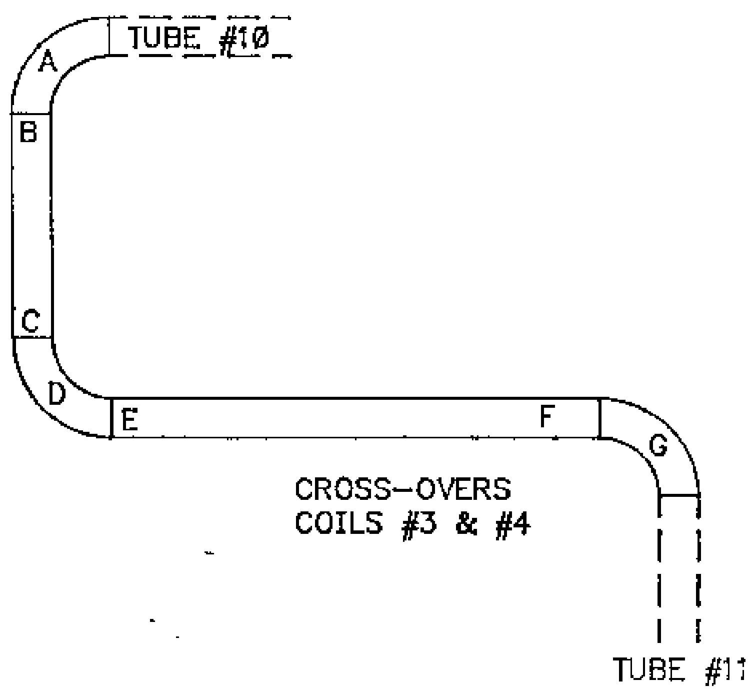
EXHIBIT. 5B

ITEM No. ____________

HEATER DESCRIPTION ____________________________________



CROSS–OVERS
COILS #1 & #2



CROSS–OVERS
COILS #3 & #4

EXHIBIT No. 5C **ITEM No. __________**

HEATER DESCRIPTION ____

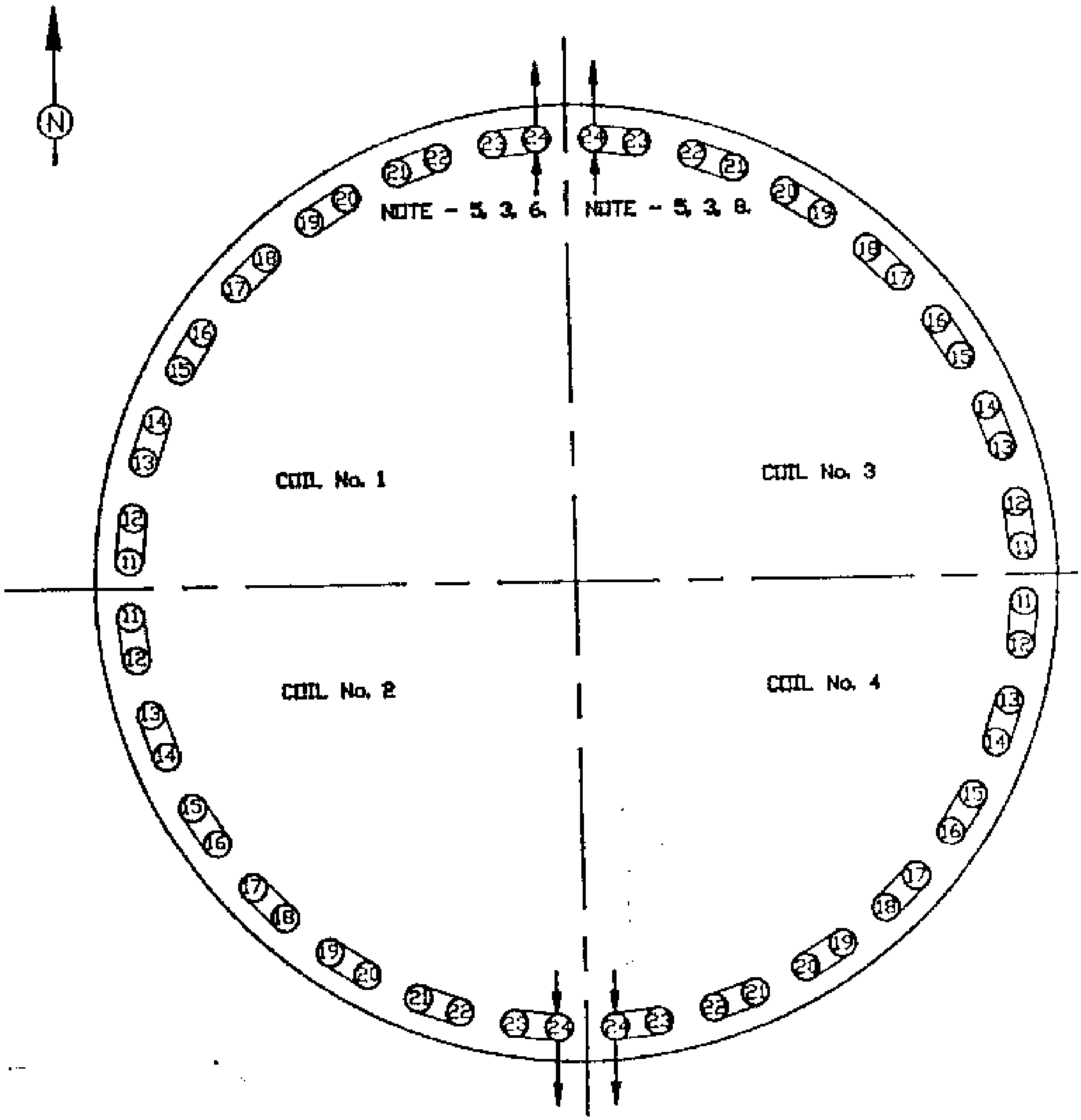


EXHIBIT NO. 6

AB-82 (side 1) 99/04

ABSA (the pressure equipment safety authority)
200, 4208 – 97 Street
Edmonton, AB T6E 5Z9

MANUFACTURER'S DATA REPORT
FOR FIRED PROCESS HEATERS

Partial ☐

Upon shipment of a Direct Fired Process Heater Unit or Part including Coil, Headers, Manifolds and Crossovers this form fully and correctly filled in must be mailed to the office of the Chief Inspector in the Province of Installation in accordance with the CSA B51 Code Para.

Manufactured by	***Name and address of Manufacturer***
Manufactured for	***Name and address of Purchaser or Consignee***
Ultimate owner	***Name and address***
Location of Installation	***Address***

Description/Type of Heater/Part	*Prov. CRN No.*	*Serial No.*	*Drawing No.*	*Year Built*	*Owner's ID No.*

Item/I.D. No.	*Design Pressure*	*Design Temp.*	*Design and/or Construction Code(s)*	*Safety Valve:*	
				Size	***Setting***

COIL

Type	*ID No.(s)*	*Tubes*				*End Closures*					*Openings Nozzles/Fitting*		
						Ret. Bends		*Plug Headers*					
		No.	*Mat'l Spec.*	*O.D.*	*Thick-ness*	*Mat'l Spec.*	*Thick-ness*	*Mat'l Spec.*	*Size*	*Thick-ness*	*Mat'l Spec.*	*Type Size*	*Rating*

HEADERS/MANIFOLDS

Type	*ID No.(s)*	*Size*	*Shell*		*Ends*		*Openings*		
			Mat'l Spec.	*Thickness*	*Mat'l Spec.*	*Thickness*	*No.*	*Type*	*Size Rating*

OTHER ITEMS (CROSSOVERS, ETC.)

Type	*ID No.*	*Size*	*Mat'l Spec.*	*Thickness*	

AB-82 (side 2) 99/04

NONDESTRUCTIVE EXAMINATION & HEAT TREATMENT

Item Description (Coil/Manifold/ Headers & Type)	*ID No.(s)*	*N.D.E.*			*Post Weld Heat Treatment*	
		Radiograph 100% or % Random	*MAG Part (MT) Dye Pen(PT).Extent*	*Other Ultrasonic, etc.*	*Temp.*	*Holding Time*

PRESSURE TEST

Item Description (Coil/Header/ Manifold & Type	*ID No.(s)*	*State whether Shop or Field*	*Hydrostatic Test Pressure*	*Pneumatic Test Pressure*	*Alternative/Additional Tests i.e. Sensitive Leak (Press and test method)*

REMARKS – *Include extent of field assembly*

Certificate of Compliance/*Certificat de conformité*

We certify that the statements made in this data report are correct and that the said vessel has been constructed in accordance with the Provincial Registered Design below and the requirements of standard CSA B51.
Nous certifions que les données de la déclaration de conformité sont correctes et que l'appareil a été construit en accord avec l'anregistrement provincial cidessous et les exigences de la norme ACNOR B51.

Provincial Registered Design
Enregistrement provincial
____

Manufacturer
Constructeur
____

Signature ____________________ **Date** ___________

Certificate of Shop Inspection/*Certificat d'inspection en usine*

I, the undersigned, a duly authorized Boiler and Pressure Vessel Inspector
Je. soussignè, inspecteur autorisé de chaudières et appareil sous pression
Employed by
Employé par ____
Of
de ____
have inspected the above vessel and state that to the best of my knowledge and belief, the manufacturer has constructed the vessel in accordance with the Provincial Registration
ai inspecté I appareil précité et autant que je sache, crois que le constructeur a construit l'appareil en accord avec l'enregistrement provincial NEC
CRN _________________ **and the requirements of standard CSA B51.**
et les exigences de la norme ACNOR B51.

Inspector's Name
Nom de l'inspecteur ____

Signature ____________________________ **Date** ______________

Certificate of Compliance/*Certificat de conformité*
Field Work ***/Installation au chantier***

We certify that the field installation of all parts of the vessel conforms with the requirements of Provincial Regulations.
Nous certifions que l'installation au chantier de toutes les composantes de l'appareil est conformé aux règlements provinciaux.

Installer's Name
Nom de l'installateur ____________________________

Signature ____________________________________

Date ____

Certificate of Field Inspection/*Certificat d'inspection Installation au chantier*

I, the undersigned, a duly authorized Boiler and Pressure Vessel Inspector
Je. soussignè, inspecteur autorisé de chaudières et appareil sous pression
Employé par
Employed by __________________________ **have inspected the items not covered by the Shop Inspection Certificate and the installation of the items and state that to the best of my knowledge and belief the construction and assembly of the items are in accordance with the Provincial Regulations.**
ai inspecté les composantes non couvertes par le certificat d'inspection en usine et l'installation de l'appareil et. Autant que je sache. la construction et l'assemblage de l'appareil sont en accord avec les règlements provinciaus. Nom de linspecteur
Inspector's Name ____

Signature ____________________________ **Date** ______________

Revision Log

Rev #	Date	Description
0	2010-09-07	Updated the contact person on page 1 – did not change the date on the document as this was considered an editorial change