Engineering Standard

SAES-K-402 8 March 2006

Centrifugal Compressors

Saudi Aramco DeskTop Standards

Table of Contents

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1 Scope

1.1 This Standard covers the minimum mandatory requirements governing the design and installation of centrifugal compressors in process air or gas service. This Standard may not be attached to or made part of purchase orders.

1.2 Centrifugal compressors in utility air service shall comply with Specification 31-SAMSS-006 and are excluded from the requirements of this Standard.

1.3 Compressor vendors shall be given a minimum of eight (8) weeks for the preparation of bids/proposals after receiving the official request for quotation.

2 Conflicts And Deviations

2.1 Any conflicts between this Standard and other Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs) or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department, Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this Standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department, Saudi Aramco, Dhahran.

3 References

Material or equipment supplied to this Specification shall also comply with applicable sections of the latest edition of the references listed below or in the body of this document.

3.1 Saudi Aramco Standards

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-B-058	*Emergency Isolation, Shutdown and Depressurization*
SAES-G-116	*Field Cleaning and Flushing of Lube/Seal Oil*
SAES-L-350	*Construction of Plant Piping*

Saudi Aramco Materials System Specifications

01-SAMSS-017	*Auxiliary Piping for Mechanical Equipment*
26-SAMSS-084	*Turbo-Compressor Oils 32, 46*
31-SAMSS-001	*Centrifugal Compressors*
34-SAMSS-625	*Vibration, Axial Position and Bearing Temperature Monitoring Systems*

Saudi Aramco Forms and Data Sheets

2812-ENG & 2812-M-ENG	*Centrifugal Compressors*

Saudi Aramco Library Drawings

DC-950041	*Pressure Indicators and Switches, Panel or Wall Mounted - Instrument Piping Details*
DC-950061	*Instrument Piping Details, Flow Meter Installations, Gas and Vapor Service (Non-Corrosive)*
DC-950062	*Instrument Piping Details, Flow Meter Installations, Gas and Vapor Service (Corrosive)*

3.2 Industry Codes and Standards

American Society of Mechanical Engineers

ASME PTC 10	*Power Test Code for Compressors and Exhausters*

4 Design

4.1 General

4.1.1 Centrifugal compressors in process air or gas service shall comply with 31-SAMSS-001.

4.1.2 Normal operating points shall be stated on the data sheets. Normal operating points shall be the performance requirements that the machine will operate at for at least 35% of the time (for example Summer and Winter conditions). A maximum of two alternative operating points (if necessary) may also be stated on the data sheets and shall be points where the machine will be required to operate for at least 10% of the time. Additional operational requirement may be stated on the data sheet for unusual but required operation for less than

10% of the time, but shall not be identified as an alternative operating point.

4.1.3 When single-lift packaged units are specified, the compressor, gear and driver shall be mounted on a single baseplate completely piped and wired after being tested under controlled conditions at the point of manufacture. Exceptions are motor drivers or steam turbines over 7,500 kW (10,000 HP) and combustion gas turbines which may be separately mounted.

4.1.4 Unit responsibility for the equipment train or single lift package shall be assigned to the compressor manufacturer. Exception may be made when the driver is a combustion gas turbine.

4.1.5 New equipment shall not generate noise in excess of 90 dB(A) at a distance of one meter after engineering controls have been implemented. If the noise level will exceed this limit, the Project Manager shall submit a completed Form 7305-ENG, Equipment Noise Data Sheet, to ECD/EPD (Environmental Compliance Division / Environmental Protection Department).

4.1.6 When mezzanine mounting is used, the piping connections shall be bottom mounted.

4.1.7 If seawater cooling is to be used, an inlet design temperature of 35°C (95°F) shall be used.

4.1.8 Unless otherwise specified, the equipment shall be designed for outdoor installation in a desert area, with relative humidity from zero to 100% (condensing) and ambient temperatures from 0°C to 50°C (32°F to 120°F). Metal temperature can reach 70°C (158°F) when exposed to direct solar radiation.

Additionally, equipment which is not enclosed or hermetically sealed and is situated offshore or near shore (i.e., within ½ km of the shoreline) shall be protected against failure due to windborne seawater spray and the accumulation of wetted salts.

4.2 Casings

The selection of horizontally split or vertically split casings should be determined by the Vendor, in accordance with 31-SAMSS-001. A relief valve should be installed on discharge piping and set to the surge pressure specified in paragraph 2.2.4 of 31-SAMSS-001. In cases where it can be shown that it is impossible to exceed the surge pressure of the machine, relief valves are not

required. In these special cases, adequate justification must be submitted for approval to the Rotating Equipment Standards Committee Chairman.

4.3 Shaft Seals

4.3.1 Seal gas shall be free from condensation and polymerization and shall be conditioned via a filtration system and pressure reduction provided by either the seal vendor or the compressor vendor. If the process gas is dirty, seal gas shall be taken from an external clean and dry source. The actual supply location shall be determined based on gas temperature, pressure and cleanliness requirements for the seal and shall be the joint responsibility of the Vendor and Saudi Aramco. In all cases, an external clean and dry seal gas must be provided by the Contractor during compressor startup and shutdown, unless otherwise approved by the Rotating Equipment Standards Committee Chairman.

4.3.2 Except for air services, a positive internal gas pressure at the seals shall be maintained under all start-up and operating conditions.

4.4 Magnetic Bearings

The use of an active magnetic bearing system for the compressor and driver shall be considered, based on an economic evaluation, when the lube oil system can be totally eliminated, resulting in a "dry" train. This will typically occur when the driver can be an expander, a variable speed motor, or a turbine. The magnetic bearing system shall be designed per the requirements of 31-SAMSS-001. Rejection of any proposal, which can meet this criterion, requires the approval of the Rotating Equipment Standards Committee Chairman.

4.5 Drivers

Specified power margins for drivers shall apply to newly purchased equipment only. Re-rate proposals reducing the power margin to meet changed process conditions shall be submitted through the Company or Buyer Representative for review and approval by the Rotating Equipment Standards Committee Chairman. Motor starting torque versus compressor suction throttled torque demand at site conditions, shall be reviewed in all cases by the Vendor and Consulting Services Department to verify start up capabilities of the train. The start up capabilities of fixed speed motor driven trains shall be verified in writing by the compressor Vendor and motor Vendor for any train with a normal suction pressure below 50 psig.

4.6 Baseplates

4.6.1 Baseplate design shall be reviewed for good access to all components for operation and for maintenance. This applies particularly to packaged units where accessibility of valves, reservoirs, pumps, etc., is of prime importance. A 3-D CAD model or large detailed 3-D drawings shall be provided by the compressor Vendor to permit review of piping, conduit runs, location of valves, etc.

4.6.2 Three (3) point supported baseplates shall be considered for offshore platforms where significant deck deflection is expected.

4.7 Control and Instrumentation

4.7.1 Controls and instrumentation shall be adequate to control the compressor at all specified operating conditions. The control method shall be determined by the process startup, shutdown and normal operation requirements. For variable speed drives, the primary process control shall be by means of variable speed operation of the compressor. For compressors with variable guide vanes, the primary process control shall be by means of varying guide vanes angle.

4.7.2 Suction throttling shall not result in sub-atmospheric pressure and risk of air ingestion into the process stream. The valve disc must, therefore, be undercut. Mechanical travel stops are not permitted. The suction throttling control valve (when required to control the suction pressure or the motor BHP) shall be located upstream of the recycle line tie-in to the compressor suction piping.

4.7.3 The anti-surge control system shall automatically maintain a flow through the compressor at a safe margin in excess of the surge flow during all operating conditions, whether the controller is in automatic or manual mode, by means of an anti-surge recycle valve and recycle line. The anti-surge system shall always be required except in the case of a recycle compressor application. In this case, the need for a recycle loop shall be evaluated by the Engineering Designer, the Plant Engineering Manager and the Rotating Equipment Division of Consulting Services Department.

4.7.4 The selection of recycle valves shall be reviewed and approved by the Process and Control Systems Department and by the Rotating Equipment Division of Consulting Services Department. Recycle valves shall be selected as follows:

a. The valve trim characteristic shall be equal percentage or linear (as recommended by the compressor or control system vendor);

b. The response time from fully closed to fully open shall be a nominal 2 seconds or less (accomplished by using volume boosters and close tubing connections, in accordance with the valve vendor's recommendations);

c. The ratio of the maximum selected valve capacity to the valve capacity demanded by the compressor surge curve (worst case scenario) shall fall between 1.8 and 2.2;

d. Recycle valves shall be specified for Class IV shutoff, unless otherwise justified by process restraints and approved by the Rotating Equipment Division of Consulting Services Department.

4.7.5 For compressor casings in series or parallel operation, individual anti-surge recycle lines shall be provided for each compressor casing. For compressor with multiple inlets or outlets, an individual recycle line for each section shall be provided as necessary.

4.7.6 For applications where quench valves are used to cool hot recycle gases, the valves must be installed as close as practical to their downstream mixing tees. The mixing tees should be installed just upstream of the suction knock-out drum, or may be located on the recycle line downstream of the recycle valve if approved by the Rotating Equipment Division of Consulting Services Department and by Process and Control Systems Department.

4.7.7 The final design of anti-surge and performance control system shall be reviewed in detail for each individual application by the compressor vendor and Rotating Equipment Division of Consulting Services Department and by Process Control Division of Process and Control Systems Department. A dynamic process simulation shall be performed for each compressor system by the Contractor, to confirm the functionality of the control system under all operating conditions. During machine shutdown, the simulation shall show that surge does not occur above 75% speed.

4.8 Piping, Valves and Interstage Cooling

4.8.1 Contractor shall be responsible and shall consult the Compressor Vendor machinery and piping engineers in order to confirm and document in conjunction with control system engineers or control

systems vendors that the following piping and hydraulic parameters are satisfied for proper compressor operation, control and protection:

a. Lag (dead) time is kept to an absolute minimum by minimizing recycle gas piping captured volume, (i.e., the volume of gas between the compressor discharge port, the discharge check valve and the recycle valve).

b. Recycle piping must be self draining (i.e., the piping is sloped downward on both sides of the surge control valve).

c. The anti-surge recycle line shall join the compressor discharge on a piping tee branch, located as close as possible to the compressor discharge. The anti-surge recycle line shall join the compressor suction line at the suction knock-out drum or suction piping upstream or downstream of knock-out drum in a 45° angled connection directing the recycle flow towards the compressor.

d. A non-slam internal-spring assisted type check valve shall be located in the discharge piping of each compressor section immediately downstream of the piping tee for the anti-surge recycle line.

e. Compressor interstage coolers and after coolers shall be located as close to the compressor discharge as possible, using minimum connecting piping volume.

4.8.2 Compressor auxiliary piping shall be in accordance with 01-SAMSS-017.

4.9 Compressor Field Sensors and Instrumentation:

4.9.1 Field instrumentation shall comply with paragraphs 4.9.2 to 4.9.5.

4.9.2 The control systems designer in conjunction with the compressor manufacturer shall be responsible for validating and confirming the type, and range of all process sensors and instrumentation used to monitor and control the compressor based on the following requirements:

a. Low loss venturi meters are the preferred means of flow measurement. However, orifice meters may be used for flow measurement. The minimum output signal from the flow (dP) transmitter at the actual surge limit line and minimum compressor speed shall not be less than 10% of the transmitters' range.

b. Smart transmitters shall be used to measure all process variables except for suction flow measurements that are used as inputs to anti-surge algorithms. Process activated switches shall only be used within the compressor skid on an exception basis when a transmitter is incapable of performing the same function. Process activated switches must be fail safe devices, incorporating hermetically sealed or encapsulated switch elements and configured to de-energize to trip.

c. Transmitters used to measure either suction or discharge flow must have a response time of 100 milliseconds or less (rise time from process measurement to 63% of transmitter calibrated range).

d. Transmitters used to measure suction or discharge pressure, temperature or differential pressure (except for flow measurement) shall be 'smart' digital devices, compensated for ambient temperature and static pressure changes. Suction temperature sensors and transmitters shall be located in the suction piping downstream of the suction knock-out drum and any piping tees. Discharge temperature sensors and transmitters shall be located close to the compressor discharge flange and upstream of any discharge cooler.

4.9.3 Vibration detectors, key phasors, shaft axial position detectors, and bearing temperature detectors and their associated monitors shall comply with 34-SAMSS-625 and 31-SAMSS-001. As a minimum, each compressor shall be fitted with two (X & Y) radial relative displacement (non-contacting) sensors, located at each journal bearing, two axial thrust position probes (one axial thrust probe for Integrally Geared Compressors) and one key phasor. Settings for alarm and shutdown shall be recommended by the compressor and driver vendors and, where applicable, the gear vendor.

4.9.4 Process connections for process pressure indicators, switches and transmitters should be in general compliance with drawing DC-950041.

Commentary Note:

Where possible, impulse lines between process taps and transmitters shall be close coupled.

4.9.5 Process connections for differential pressure transmitters should be in general compliance with drawing DC-950061 and DC-950062.

Commentary Note:

Where possible, impulse lines between primary sensors and transmitters shall be close coupled and self draining.

4.10 Compressor Performance and Anti-Surge Control Requirements

4.10.1 All centrifugal compressors, with the exception of recycle compressors where an anti-surge loop may not be required (paragraph 4.9.3), shall have a pre-engineered, stand-alone or compressor train integrated, fail-safe and fault tolerant digital anti-surge and performance control system (a DCS anti-surge controller is not acceptable). This anti-surge and performance control system shall optimize compressor operation and load, but act to decrease network resistance whenever the compressor operating point moves too close to its pre-defined surge limit. The decrease in network resistance shall be accomplished by modulating a properly sized recycle or spill-back valve which has a nominal stroking time from the closed to full open position of 2 seconds. Anti-surge controllers must execute their respective algorithms within 100 milli-seconds (which includes sampling inputs, executing logic, and initiation of output change). The sampling time shall be less than 40 milli-seconds.

4.10.2 Each compressor casing or section provided with a recycle line (paragraph 4.7.5) shall have an anti-surge control system. Anti-surge control systems for multiple stages/sections may reside in a single controller.

4.10.3 Where compressors are operated in parallel arrangements, a load sharing controller shall function to distribute the load by keeping each machine equidistant from its surge curve or surge control margin.

4.10.4 The control system shall be able to respond to all required process parameters and dynamics (i.e., startup, normal operation, normal shutdown, and emergency shutdown) in automatic mode. The control system shall satisfy the compressor manufacturer's operational requirements for performance and surge avoidance whether in automatic or manual modes of operation.

4.10.5 Anti-Surge Controller Action

4.10.5.1 The anti-surge controller shall be capable of building, constructing or inputting a surge curve (d/P, pressure ratio, or polytropic head vs. suction flow), based on the compressor manufacturer's predicted surge curve data, and maintaining control at a user selectable surge control line

which usually is 10% margin away from the actual operating surge curve of the compressor in its safe operational zone.

4.10.5.2 The anti-surge controller shall be capable of incorporating incipient surge detection logic, or functionally similar types of detection schemes to evaluate potential instability in compressor operation. Such schemes should be capable of initiating action to drive the recycle valve towards its full open position upon validation of an incipient surge condition. Several potential schemes or combinations thereof are rate of change of flow or pressure.

4.10.5.3 The compressor's actual surge limit line shall be determined for one or more operational conditions during factory acceptance or site acceptance testing of the compressor. Based on actual process testing and process parameters, the surge control line shall be reconstructed within the anti-surge controller and the surge control margin revalidated.

4.10.5.4 The anti-surge controller shall act to maintain the recycle valve in a closed position during normal operation and normal loads.

4.10.5.5 In the event of abnormal loads or process upsets which cause the compressor's operating point to rapidly approach or cross over the surge control line towards its actual surge curve, the controller shall measure the rate of change in the operating point, and respond by driving the recycle valve to its full open position.

4.10.5.6 Control strategies for safe operating regions shall include proportional, integral and/or derivative (if necessary). Control strategies for potentially unsafe regions (i.e.; between the surge control line and actual surge curve) shall include non-linear or exponential gain, open loop (step) response or similar strategies.

4.10.5.7 Control action for all algorithms, including transfer from automatic to manual, and back to automatic, shall be smooth and bumpless.

4.10.5.8 Recycle valve shall follow a user configurable closure rate which is nominally in the range of 30 to 60 seconds.

4.10.5.9 Anti-surge controllers shall be configured to initiate an alarm and increment a surge counter when an actual surge cycle has been detected. The surge count accumulator contents shall be protected from being accidentally reset by password, keylock or similar methods of security.

4.10.5.10 The anti-surge control algorithms shall incorporate functionality to automatically evaluate operation of the controller at or near the surge control line and to automatically increase the surge control margin to prevent unstable compressor operations. Automatic adjustments of the surge control margin shall be alarmed to the operators. The system shall maintain a record of the previous margin settings on hard-disk or non-volatile memory.

4.10.5.11 Anti-Surge and Performance Controller Algorithms and Configuration.

a. The anti-surge and performance control system shall consist of one or more controllers with a pre-engineered menu of algorithms designed to perform surge control, coordination, load-sharing and de-coupling between multiple sections or multiple compressors in series or parallel configurations.

Commentary Note:

Individual control algorithms for multi-stage or multiple compressors may be installed within a single multifunction or programmable controller, provided it incorporates a fault-tolerant, backup scheme (e.g., dual or triplicated controllers and I/O) with bumpless transfer. All controllers shall incorporate safety and security features that prevent their unauthorized alteration.

b. The pre-engineered menu of algorithms shall as a minimum consist of the following, applicable to all compressor stages:

1. Suction flow (volumetric) vs. compressor head or dP (Discharge Pressure - Suction Pressure).

2. Suction flow vs. compressor pressure ratio (outlet/inlet pressure).

3. Suction flow vs. compressor polytropic head.

4. Fall-back strategies for constant or variable speed compressors with fixed or variable gas composition and suction flow measurement:

   i. Upon failure of or invalidation of suction flow transmitter signals, the controller shall revert to either minimum recycle flow or a fixed suction flow.

   ii. Upon failure of or invalidation of the suction pressure transmitter signal, the controller shall revert to minimum recycle flow.

   iii. Upon failure of or invalidation of the discharge pressure transmitter, the controller shall revert to a specified compression ratio.

   iv. Upon failure of or invalidation of the compressor rotational speed input, the controller shall revert to a fixed speed.

   v. Loss of or invalidation of any inter-stage suction flow measurement will result in an adjacent stage's flow computation being used for control purposes.

5. Performance controller algorithms shall include features for automatic startup, staging, and shutdown of the compressor(s); including necessary control loop de-coupling, load sharing and compressor balancing arrangements.

c. The anti-surge control system shall be designed such that it accounts for the following characteristics and constraints of compressor, piping and control system:

   1. Compressor performance curves, based on process parameters (fluid data), at the most severe operating region (i.e., startup, shutdown, minimum flow, or full recycle);

2. Compressor driver characteristics and speed feedback devices (e.g., turbine or electric motor - constant speed or variable speed);

3. Recycle (pipe) volumes (minimum acceptable);

4. Recycle gas cooling or required temperature quenching;

5. Location of the compressor discharge check valve;

6. Recycle valve sizing, characteristics, response time, and fail safe modes;

7. Incipient surge algorithm (paragraph 4.10.5.2);

8. Suction measurement element, transmitter range and response time;

9. Compressor suction and discharge, pressure and temperature measurement ranges and locations;

10. Fall back strategy(s) upon flow transmitter, suction or discharge pressure transmitter failure or fault detection;

11. Bumpless transfer and fallover from primary controller to backup controller upon the failure of the primary controller, transfer from automatic to manual to automatic; with minimum flow fall-back strategies.

4.10.6 Anti-Surge and Performance Controller Support Software.

Supporting software or software tools shall be provided in conjunction with associated anti-surge and performance controllers which allow on-line monitoring and real-time display of compressor maps and which show current operating conditions and limits. This software shall be capable of initiating data acquisition and archiving critical compressor operational parameters in real-time at the controller's sampling rate. The software shall also be capable of performing critical event archiving, event alarming and multiple trend building/display.

4.11 Local and Remote Compressor Instrument Control Panels

Pressure gauges and local control instrumentation, where specified, shall be mounted on a local gauge board.

5 Installation

5.1 Emergency shutdown and isolation systems shall be provided in accordance with SAES-B-058. Power-operated emergency isolation block valves shall be located upstream of the suction knock-out (K.O.) drum and downstream of the discharge K.O. drum (if provided). The recycle line shall tie-in downstream of the suction isolation valve and upstream of the discharge isolation valve.

Commentary Note:

Emergency isolation valves shall not be installed within the recycle loop of a compressor or any of its sections.

5.2 An automatic vent valve, that is actuated via an emergency shutdown (ESD) signal, shall be located on the suction K.O. drum or on the discharge piping between the compressor and any power actuated valve.

5.3 A temporary stainless steel conical strainer of adequate strength shall be installed, during commissioning, in the compressor suction line upstream of performance pressure sensor. This strainer has to be mounted into a drop-out pipe spool.

5.4 All compressor pressure and temperature sensors used for performance or surge control monitoring shall be installed at a maximum distance of ten pipe diameters and a minimum of two pipe diameter from the compressor flanges; except for suction temperature sensor which shall be installed upstream of the suction strainer. In addition, pressure measuring points located downstream of devices that can cause flow disturbance which could result in measurement inaccuracy, such as valves, orifices, strainers, elbows, shall be at least three pipe diameters distant from them. Pressure and temperature measuring devices shall be oriented 90 degrees apart.

5.5 Piping connections to the compressor nozzles shall be made in accordance with SAES-L-350, taking into account the specific flange fit up and bolting tolerances. No piping supports or support structure shall be placed over upward facing compressor nozzles that would restrict access for maintenance of the complete equipment skid. Each compressor nozzle shall be provided with an individual, removable, final piping spool. Allowable forces and moments on the compressor nozzles shall be per API STD 617 appendix G, when the forces and moments are resolved to the largest nozzle.

5.6 All compressor suction piping between the suction drum and the compressor inlet shall be cleaned by high pressure hydrojetting following fabrication. All

field fabricated piping forming any part of the buffer gas system to compressor dry gas seals or tertiary shaft seals shall be manually cleaned or cleaned by high pressure hydrojetting, or chemically cleaned and neutralized. Lube oil systems shall be cleaned in accordance with SAES-G-116.

5.7 Contractor shall provide a fire detection system for compressors handling combustible gases. The system selection shall be reviewed with Saudi Aramco's Chief Fire Prevention Engineer.

6 Shop Testing And Inspection

6.1 Hydrostatic Tests

Hydrostatic tests shall be required for all pressure containing parts as listed in the Inspection & Testing Plan (ITP).

6.2 Mechanical Running Test

A mechanical running test shall be mandatory and always witnessed.

6.3 Performance Test

A performance test shall be specified and witnessed for each compressor duty. For a series of identical units, only one compressor requires performance testing. Tests shall be in accordance with ASME PTC 10. Tests shall be to Type II unless otherwise specified. where rotor instability due to high gas densities could be encountered, either a Type I test or, as an alternative, Type II test plus a "Similar Density" test shall be considered. The Rotating Equipment Division of Consulting Services Department shall be consulted concerning advisability of Type I full load, full pressure tests in these circumstances. The extra costs of such tests, compared to a Type II test, shall be weighed against the cost (and delay) to correct any mal-performance after the compressors are installed.

6.4 String Test

A string test requires the approval of the Rotating Equipment Standards Committee Chairman. The mechanical running test is not required for the string tested machines.

6.5 Shop Noise Level Test

A noise level shop test shall be conducted for reference only.

7 Field Testing

7.1 Performance Test

As soon as possible after the installation is completed, a field performance test shall be conducted on the compressor. The performance shall be checked at a minimum of five points and shall include design, surge and overload points. For variable speed drivers the test shall be conducted at normal speed. The vendor shall be present for the test and shall verify that the data is taken in an acceptable manner.

Commentary Note:

Field test data is subject to inaccuracies of up to 10% due to location and calibration of critical instrumentation. To minimize these inaccuracies, the instrumentation should be calibrated and checked just before and just after the tests. Gas samples should be taken for each test point.

7.2 Mechanical Test

Overall vibration levels in the field shall not exceed 125% of the maximum factory acceptance limits of API STD 617 when the machine is operating within its operating range.

7.3 Noise Level Test

The noise level test shall be conducted in the field.

8 Life Cycle Cost Evaluation

Quotations for compressors of 1000 HP and larger shall be evaluated on the basis of a Life Cycle Cost (LCC). This cost is composed of initial cost of the compressor plus the present worth of the consumed power cost over an operating period of 20 years. The Life Cycle Cost of the compressor shall be determined using the life cycle cost spreadsheet LCC-005 or LCC-006.

Revision Summary

8 March 2006 Major revision.