DESIGN OF PROPYLENE GAS PIPELINE SYSTEM

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COLLEGE OF ENGINEERING

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

ENERGY ACRES, DEHRADUN

MAY 2008

DESIGN OF PROPYLENE GAS PIPELINE SYSTEM

A thesis submitted in partial fulfillment of the requirements for the Degree of
Master of Technology
[Pipeline Engineering]

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30th April 2008

To whomsoever it may concern

This is to confirm that Mr. A Selvam who is a final year M.Tech student of "UNIVERSITY OF PETROLEUM AND ENERGY STUDIES, Deharadun, has done his academic project on ESSAR in our company along with our team from 24th March 2008 to 30th April 2008.

for Saipem India Projects Ltd.

M Srinivasarao
Manager HR & Organization

CERTIFICATE

This is to certify that work contained in this thesis titled "Design of Propylene Gas Pipeline System" has been carried out by Mr.A.Selvam under my supervision and has not been submitted elsewhere for a degree.

22/05/2008

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A.Selvam
M.Tech [Pipeline Engineering]

ABSTRACT

In the Basic Engineering Package [BEP] process calculations such as Line sizing, Velocity, Pressure calculations, Preparation of Process & Instrumentation Diagram [P&ID] etc has been carried out. After this, it has been forwarded to the Piping department to carry out the Equipment layout, Pipe routing, Isometric Drawing preparation, modeling of the pipelines in Caesar II software to carry out the stress analysis. In the stress analysis proper supports has to be provided in order to check all the stresses are with in the safer specified limits of the ASME code. Finally after checking all the parameters it has been forwarded to the site for construction activities.

This project covers the major activities of the process and piping department for designing a 10 Km propylene gas pipeline for the transportation of 16.68 MSCMD of propylene gas from the refinery complex to the near by petrochemical units to meet the supply and demand in order to increase the productivity.

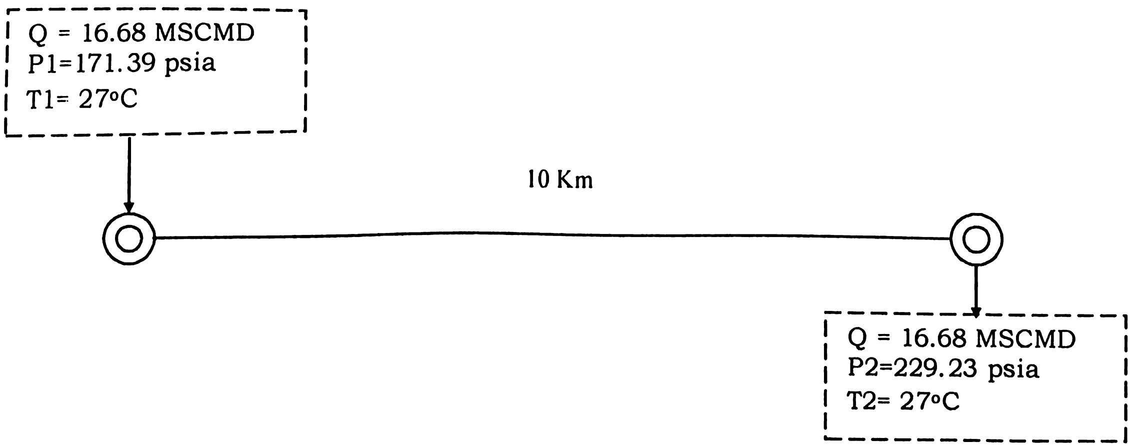


Figure – Pipeline Design Profile

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

NOMENCLATURE

Q_b – Gas flow rate ft^3/hr

D_i – Pipeline inner diameter inch

D_O – Pipeline Outer diameter inch

L – Length of the Pipeline ft

t – Thickness of line pipe inch

P – Pressure at any section psia

P_1 – Pressure at inlet section psia

P_2 – Pressure at outlet section psia

T_f – Flowing Gas temperature ^oR

u – Gas Velocity ft/sec

ue – Erosional Gas Velocity ft/sec

Z_1 – Compressibility Factor at suction condition

Z_1 – Compressibility Factor at discharge condition

G – Gas Gravity

R – Gas Constant = 10.73 ft^3* psia/lbmoles* ^oR

η_a – Adiabatic Efficiency

η_o – Overall efficiency

η_m – Mechanical efficiency

S – Yield strength of the pipe material psi

F – Basic Design Factor

E – Longitudinal joint factor

T – Temperature deaerating factor

S_L – Longitudinal stress, MPa (psi)

S_H – Hoop stress, MPa (psi)

W – Distributed weight of pipe material, contents and insulation, N/m (lbs/ft)

n – Conversion factor, 10^{-3} m/mm (1 ft/12 in)

γ – Heat Capacity

Z – Pipe section modulus, mm^3 (in^3)

S_E – Displacement stress range, MPa (psi)

S_A – Allowable displacement stress range, MPa (psi)

f – Stress reduction factor

S_c – Basic allowable stress of minimum material temperature, MPa (psi)

S_h – Basic allowable stress at maximum material temperature, MPa (psi)

N – Equivalent number of full displacement cycles during the expected service life, $< 2 \times 10^6$

S_b – Resultant bending stress, MPa (psi)

S_t – Torsional stress, MPa (psi)

i_i – In plane stress intensity factor

M_i – In plane bending moment, N-m (lb-ft)

i_o – Out plane stress intensity factor

M_o – Out plane bending moment, N-m (lb-ft)

M – Torsional moment, N-m (lb-ft)

Y – Resultant of total displacement strains, mm (in)

L_s – Straight line distance between anchors, m (ft)

K – Constant, 208.3 for SI units

S_N – Longitudinal stress from sustained and occasional loads, MPa (psi)

1. INTRODUCTION

There are a lot of users of polymer grade propylene in India, while propylene is in short supply. The pipeline will help all propylene producers and consumers to better manage supply/demand balances and also improve the industry's overall competitiveness. The major propylene derivatives are enjoying healthy markets. Especially polypropylene, which is 50 percent of propylene's take. Plentiful supply, competitive cost, and versatility continue to support an upward trend in the consumption of propylene on a worldwide scale. Increasing, production of propylene gas in the world and the consumption by the petrochemical industries has been transported by pipelines or in liquid form in ships.

This project is aimed to ensure the uninterrupted supply of propylene gas to the nearby petrochemical and polymer industries. For this pipelines are the most efficient, safer and cheaper way of transportation. This project addresses the design of propylene gas pipeline and the compressor station piping layout, piping routing and stress analysis of compressor station piping for the transportation of 16.68 MSCMD propylene gas. Piping inside the boundaries of a chemical plant, refinery, or gas processing plant falls under the scope of ASME B31.3 – Process piping and ASME B31.8, covering gas transmission and distribution piping systems.

Unattended pumping stations move large volume of oil and petroleum products under high pressure. Similarly, gas transmission system supported by compressor stations, deliver large volume of gas to large distance.

Many factors have to be considered in the design and engineering of long distance pipelines, including the nature and volume of fluid to be transported, length of the pipeline, the type of the terrain traversed and the environmental constraints. Construction procedures for most pipeline systems can be adapted to consider specific environmental conditions and are tailored to cause minimal impact on the environment.

2. LITERATURE REVIEW

The use of pipelines has a long history, more than 1,000 years ago, the Romans used lead pipes in their aqueduct system to supply water to Rome. Introduction of steel pipe in the 19^{th} century, which greatly increased the strength of pipes of all sizes

Major innovations in pipeline technology made since 1950

- Introduction of new pipeline materials such as ductile iron and large diameter concrete pressure pipes for water, and PVC (polyvinyl chloride) pipe for sewers
- Use of pigs to clean the interior of pipelines and to perform other functions
- Batching of different petroleum products in a common pipeline
- Application of cathodic protection to reduce corrosion and extend pipeline life
- Use of large side booms to lay pipes, machines to drill or bore under rivers and roads for crossing, machines to bend large pipes in the field, x-rays to detect welding flaws, and so forth.

Existing Propylene Pipeline

The Lou-Tex propylene pipeline is a 263-mile, 10" pipeline that transports chemical grade propylene from Sorrento, La., to Mont Belvieu, Texas.

Lou-Tex, a common carrier pipeline regulated by the Federal Energy Regulatory Commission, transports chemical grade propylene produced from the petrochemical and refinery corridor along the Mississippi River between Baton Rouge and New Orleans to the larger petrochemical complex east of Houston.

Propylene Production

Global propylene demand typically grows at about 5%/year. Due to their large economic bases, North America, West Europe, and Northeast Asia are the largest producing and consuming regions.

Propylene is produced mostly from steam crackers as an ethylene by-product. Refinery FCC units are the other dominant global supplier of propylene, as a by-product of motor gasoline and distillates production.

Products

Polypropylene production for mechanical parts, containers, fibers, and films is the primary consumer of propylene. Other important propylene consumers include acrylonitrile, propylene oxide, oxo-alcohols, cumene, and acrylic acid.

Propylene supply

By 2010, global propylene supplies will reach 83.7 million tones. Most of the new capacity additions will be in Asia (38%), the Middle East (30%), and North America (10%).

Propylene demand

Global propylene demand continues to grow strongly during the next 5 years, as global economies recover and pent-up demand by consumers further influences the petrochemical industry.

Transport, safety and environment benefits

- Decongestion of road, rail and waterways
- Allowing olefins derivatives (consumer goods) to be produced close to market and consumers
- Decoupling economic growth and transport growth
- Olefins ultimately end up in consumer goods and are linked to economic growth

Safety

- Safest mode of transport if integrity well managed
- Underground transport isolated from general public

Reducing emissions

- Pipelines emissions very low vs. other modes of transport (CO_2 graph)
- Reduction of environmental impact
- No impact on country side after installation

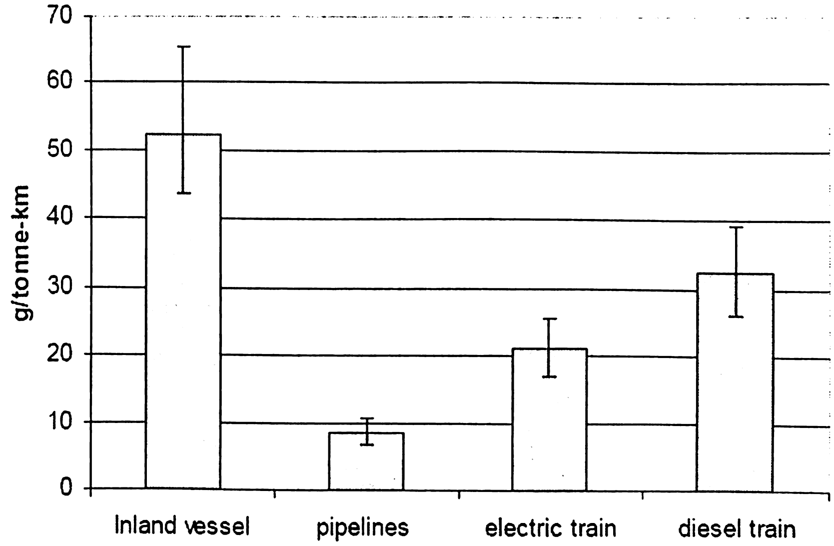


Figure - 01 CO_2 Emission by various transport modes

A pipeline network provides the opportunity to run plants at higher operating rates

3. THEORITICAL DEVELOPMENT

3.1 CODES AND STANDARDS

Pipelines and related facilities expose the operators and potentially the general public to the inherent risk of high pressure fluid transmission. As a result national and international codes and standards have been developed to limit the risk to a reasonable minimum. They are not intended to be substitutes for good engineering practices for safe design.

The codes and standard have been followed in the design, construction, operation and maintenance of gas pipeline are

ISO 13623 - Petroleum & Natural gas industries – Pipeline transportation systems.
ASME B 31.8 - Gas Transmission and Distribution Piping Systems.
API 5L - Specifications for Line pipe
API 617- Axial and Centrifugal compressors and expander – compressors for petroleum, chemical and gas industry applications
ASME B 31.3 – Process Piping

DESIGN CALCULATION

3.2 PIPELINE SIZING

Pipe Diameter [Di] $= \{1.44 * 10^{-3} * [Q_b * Z * T_f / P * u]\}$ ^ $^{0.5}$

Where,
Q_b – Gas flow rate ft^3/hr
D_i – Pipeline inner diameter inch
P – Pressure at any section psia
T_f – Flowing Gas temperature ^oR
u – Gas Velocity ft/sec
Z – Compressibility Factor

3.3 EROSIONAL VELOCITY

The Erosional velocity represents the upper limit of gas velocity in a pipeline. As the gas velocity increases, vibration and noise result. Higher velocities also cause erosion of the pipe wall over a long time period. The Erosional velocity (ue) may be calculated as follows

Erosional velocity [ue] = 100/[29*G*P/Z*R*T]^0.5

Where, P – Minimum Pressure at any section psia

T_f – Flowing Gas temperature °R

ue – Erosional Gas Velocity ft/sec

Z – Compressibility Factor

G – Gas Gravity

R – Gas Constant = 10.73 ft^3* psia/lbmoles* °R

The recommended value for the gas velocity for the gas pipelines is 40 – 50 % of the Erosional velocity or for 50- 60 % of the Erosional velocity for non major mainlines [i.e. 15-17 m/s]

Gas operating velocity [u] = Erosional velocity [ue] * 0.6

3.4 OPERATING VELOCITY

Gas operating velocity [u] = $1.44 * 10^{-3} * [Q_b * Z * T_f / P * Di^2]$

3.5 REYNOLDS NUMBER

The Reynolds number can be used to check the flow regime of the gas transmission pipeline

$Re = [45 * Q_b * G] / D_i$

Where Q_b – Gas flow rate ft^3/hr

D_i – Pipeline inner diameter inch

G – Gas Gravity

If the calculated value of the Reynolds number is more than 4000 than the flow is fully turbulent.

3.6 TRANSMISSION FACTOR

The transmission factor for fully turbulent flow is given by Nikuradse equation as

$[1/f]^{0.5} = 4*\log[3.7*Di/Ke]$

Where [1/f] – Transmission Factor

Di – Pipeline Inner Diameter inch

Ke – Effective Roughness inch

The Nikuradse equation shows that if the effective roughness of the pipe is increased, the transmission factor decreases and results in higher pressure drop. By decreasing the effective roughness, higher transmission factor or lower pressure drop is obtained

The effective roughness that is measured and used for uncoated commercial pipes are with in the range of 650 -700 micro inches

3.7 PRESSURE CALCULATION

Steady State Flow Equation: Panhandle A Equation

Panhandle A equation is normally used for medium to relatively large diameter pipeline, operating under medium to high pressure. These equations have been successfully used for Reynolds numbers in the range of 4 million to 40 million.

$P_1^2 - P_2^2 = K_1 Q_b^n$

$R = 2.552 * 10^{-4} * T_f * Z * [G^{0.855} / Di^{4.856}]$

$n = 1.855$

$K_1 = R * L$

Where, Q_b – Gas flow rate ft^3/hr

D_i – Pipeline inner diameter inch

L – Length of the Pipeline ft

P_1 – Pressure at inlet section psia

P_2 – Pressure at outlet section psia

T_f – Flowing Gas temperature ^oR

Z – Compressibility Factor

G – Gas Gravity

3.8 COMPRESSOR CALCULATION

The compressor compresses the gas and raises its pressure (and its temperature) to the level required to ensure that the gas will be transported from one point to another point, such that the required outlet pressure can be maintained. The higher the outlet pressure at destination, the higher will be the pressure required at source. This will cause the compressors to work harder. The energy input to the gas by the compressors will depend upon the compression ratio and gas flow rate, among other factors.

3.8.1 COMPRESSION RATIO

Generally the compression ratio is limited to 1.2 to 1.8 for centrifugal compressors

Compression Ratio R = Discharge Pressure/Suction Pressure

3.8.2 ADIABATIC EFFICIENCY

The adiabatic efficiency can be calculated, knowing the actual discharge temperature of the gas, suction and discharge pressures and the compressibility factors, using the following equation

Adiabatic Efficiency $[\eta_a] = (T_1/ T_2 - T_1)*(Z_1/Z_2/)*\{(P_2/P_1) \wedge (\gamma - 1/ \gamma)-1\}$

3.8.3 HORSEPOWER REQUIRED

From the energy input to the gas, following equation is used to calculate the compressor HP

$HP = 4.0639*(\gamma/ \gamma - 1)*Q*(Z_1+Z_2/2)*T_1*(1/ \eta a)*\{(P_2/P_1) \wedge (\gamma - 1/ \gamma)-1\}$

Where HP – compression horsepower

γ – Cp/Cv the ratio of specific heats of gas

Q – Gas flow rate, MSCMD

T_1 – Suction temperature of gas, ^oK

P_1 – Suction pressure of gas, psia

P_2 – Discharge pressure of gas, psia

Z_1 – Compressibility of gas at suction conditions, dimensionless

Z_2 – Compressibility of gas at discharge conditions, dimensionless

η_a – Compressor adiabatic efficiency

3.8.4 BRAKE HORSEPOWER (BHP)

Taking into account a mechanical efficiency ηm of the compressor driver, the Brake Horsepower (BHP) required may be calculated as follows

$BHP = HP/\eta_m$

3.8.5 OVERALL EFFICIENCY

The mechanical efficiency ηm of the driver generally varies from 0.95 to 0.98. By multiplying the two efficiencies, we get the overall efficiency $[\eta o]$ as follows

Overall efficiency $[\eta_o] = \eta_a \times \eta_m$

3.9 STRENGTH OF PIPE

The internal pressure in a pipe is limited to what the pipe material and wall thickness can withstand at a certain temperature. As the pipe pressure is increased, the stress in the pipe material increases. Ultimately, at some internal pressure the pipe will rupture. Therefore for each pipe size and wall thickness, depending upon the pipe material, there is a safe internal pressure beyond which it is not advisable to operate the pipeline. This is known as the maximum allowable operating pressure (MAOP), sometimes shortened to maximum operating pressure (MOP).

There are two stresses developed in a pipe wall due to internal pressure. The larger of the two is called the hoop stress and acts in the circumferential direction. The second is the axial or longitudinal stress that acts along the axial direction. The axial stress is one-half the magnitude of the hoop stress.

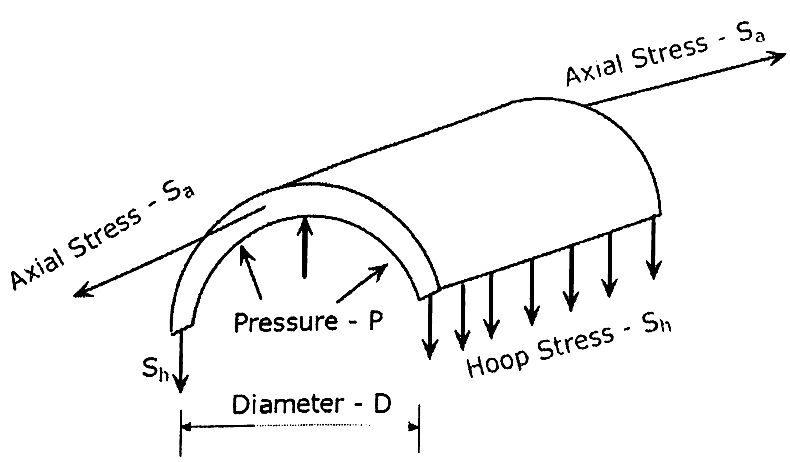


Figure – 02 Pipe stresses due to internal pressure

3.9.1 HOOP STRESS

The allowable internal pressure can be easily calculated using the Barlow's equation as follows.

S_H = [P* Do]/ [2*t]

Where, S_H –Allowable hoop stress in pipe, psia

P – Allowable internal pressure, psia

Do – Pipe outside diameter, inch.

t – Pipe wall thickness, inch.

3.9.2 LONGITUDINAL STRESS

The longitudinal stress, S_L can be calculated from a the below equation as follows

S_L = [P* D]/ [4*t]

It must be noted that unlike the General Flow equation or other flow equations, the diameter used here is the outside diameter, not the inside diameter. In practice, to calculate the internal design pressure for a gas pipeline, we modify the Barlow's equation slightly by introducing some factors that depend upon the pipeline manufacturing method, operating temperature and the class location of the pipeline. The modified equation is as follows

Thickness [t] = [P* D]/ [2*S*F*E*T]

3.10 THICKNESS CALCULATION

Thickness of the line pipe is calculated as per ASME B 31.8

t = [P* D]/ [2*S*F*E*T]

Where, Do – Pipeline Outer diameter inch

t – Thickness of line pipe inch

P – Pressure at any section psia

S – Yield strength of the pipe material psi

F – Basic Design Factor

E – Longitudinal joint factor

T – Temperature deaerating factor

Location Class 1

A Location Class 1 is any 1 mile section that has 10 or fewer buildings intended for human occupancy. A Location Class 1 is intended to reflect areas such as wasteland, deserts, mountains, grazing land, farmland, and sparsely populated areas.

Division 1

A Class 1 location where the design factor of the pipe is greater than 0.72, but equal to or less than 0.80, and which has been hydrostatically tested to 1.25 times the maximum operating pressure.

Division 2

Class 1 location where the design factor of the pipe is equal to or less than 0.72 and which has been tested to 1.1 times the maximum operating pressure.

Location Class 2

A Location Class 2 is any 1 mile section that has more than 10 but fewer than 46 buildings intended for human occupancy. A Location Class 2 is intended to reflect areas where the degree of population is intermediate between Location Class 1 and Location Class 3 such as fringe areas around cities and towns, industrial areas, ranch or country estates, etc.

Location Class 3

A Location Class 3 is any 1 mile section that has 46 or more buildings intended for human occupancy except when a Location Class 4 prevails. A Location Class 3 is intended to reflect areas such as suburban housing developments, shopping centers, residential areas, industrial areas, and other populated areas not meeting Location Class 4 requirements.

Location Class 4

Location Class 4 includes areas where multistory buildings are prevalent, and where traffic is heavy or dense and where there may be numerous other utilities underground. Multistory means 4 or more floors above ground including the first or ground floor.

Basic Design Factor [F]

Location Class	Design Factor
Location Class 1, Division 1	0.80
Location Class 1, Division 2	0.72
Location Class 2	0.60
Location Class 3	0.50
Location Class 4	0.40

Table 01 – Basic Design Factor [F]

Longitudinal Joint Factor [E] for API 5L

Pipe class	E Factor
Seamless	1.0
Electric resistance welded	1.0
Electric flash welded	1.0
Furnace butt welded	0.6
Submerged arc welded	1.0

Table 02 – Longitudinal joint Factor [E]

Temperature Derating Factor [T] for Steel Pipe

Temperature °C	T Factor
121 or less	1.000
149	0.967
177	0.033
204	0.900
232	0.867

Table 03 – Temperature Derating Factor [T] for Steel Pipe

3.11 COMPRESSOR STATION PIPING LAYOUT & DESIGN

Piping design and equipment arrangement are interrelated subjects that cannot be well taught in the classroom. Most good designers throughout history have learned their profession by a combination of academic and practical work. The use of previous designs and drawings is a good way to learn and improve on current designs.

The experienced piping designer needs to have a working knowledge of plant layout, equipment arrangement, and system functionality associated with one or more fields of endeavor, such as commercial, industrial, refinery, petrochemical, or power. In addition, the designer must have an understanding of the practical application of piping materials, valves, pumps, tanks, pressure vessels, heat exchangers, power boilers, vendor-supplied skid assemblies, steam turbine drivers, and other machinery and equipment.

CENTRIFUGAL COMPRESSOR

Inlet Piping

With higher compressor velocities and rotating speeds the plant layout designer must give greater consideration to the compressor inlet line piping. The ASME test code requires a minimum of three diameters of straight run piping between the elbow and the inlet nozzle. However, such factors as gas velocities, molecular weight and temperature must be considered for optimum layout. An equipment engineer should be consulted at the outset to develop a base case layout requirement. The preferred design is one in which the horizontal run is parallel to the compressor shaft. Another factor that could influence the straight run requirements is the need to inject wash water into the gas stream to clean compressor blades.

Suction Line strainers

Compressor suction lines must be free from any foreign particles that could damage the internals of the machine. Strainers are installed in the inlet line between the block valve and the compressor inlet nozzle. If the strainer is of permanent type, a clean out connection must be added to remove any trapped foreign matter during a shutdown of the compressor.

Break-Out flanges

All lines to the compressor that must be removed for maintenance of the compressor or strainer removal must have a set of flanges in the line in addition to the set at the compressor nozzle

Straightening Vanes

When the straight run on the inlet piping is less than desired, a straightening vane may be installed to smooth the flows and improve the compressor performance. This vane must be in accordance with ASME standards. If the use of vanes can be tolerated, the length for any arrangement can be divided by four.

3.12 CONSIDERATIONS FOR PIPING LAYOUT

1. Project Client and Owner Requirements

Most projects have project-specific requirements imposed by the owner. These usually include additional requirements above the codes and standards which may have direct impact on both pipe layout and equipment location. Most of these requirements derive from operations feedback which the owner contractually invokes on future projects. Owners may not have a thorough understanding of all the levels of detail required to produce a piping design, but they know the finished product. It is very important that all project personnel and designers know and understand these requirements.

2. System Piping and Instrumentation Diagrams (P&ID)

These are the schematic single line process diagrams which define the sequence of equipment, valves, inline components, pipeline sizes, and overall system arrangement required for proper system function.

3. P&ID Implementation and Physicalization

Piping and instrumentation diagrams are the piping designer's roadmap for laying out piping systems. The designer should understand the P&ID and the specific system characteristics. With this knowledge the designer is required to develop the P&ID and arrange connections and branches as required to best suit the process to actual physical design.

4. Project Piping Specifications

These documents or databases define the following essential information

- System design and operating pressures and temperatures
- Piping materials
- Pipe wall thickness or schedules
- Types of fittings to be used, e.g., butt weld, socket weld, or screwed
- Valve and flange pressure rating and insulation requirements
- In addition, the piping specification defines the fabrication, examination, testing, inspection, and installation requirements, including the requirements for seismic installations, where applicable.

5. Equipment Outlines

These documents can be either imported computer-aided design or drafting (CADD) files or prints of the equipment being piped. They include overall dimensions and the pipe size, wall thickness, flange pressure rating, and locating dimensions of all pipe nozzles and other connections.

6. General Arrangements or Equipment Location Drawings

These drawings will indicate the location of all major pieces of equipment in the plant which the designer will either verify or relocate, as required, to accommodate the physical pipe routing as designed or redesign the piping to accommodate the particular piece of equipment. Generally equipment location drawings are developed by senior-level piping designers during the proposal preparation and are taken over by the project team upon award of the contract. From this point on they are revised and updated as part of the normal process of design development. Equipment should be arranged with the piping layout in mind. Equipment locations and relational arrangements should be evaluated during the piping layout design process. Adjustments and occasionally major changes to equipment arrangement are required to solve major piping arrangement problems. Piping system design is dependent on the input from numerous reference sources prior to the start of piping design.

7. Piping Layout Considerations and Planning Studies for Improved Piping Economics

Proper planning is an important activity performed by the piping designer in the early stages of a project. Space conservation and a symmetric piping arrangement are achieved when all the systems are evaluated in the preliminary stages of design. This study will become the final design. It is important to consider the cost of the piping material at this time for the expensive lines. These lines should be kept as short as possible, while maintaining proper piping flexibility even if this requires changing the equipment arrangement.

Piping layout then becomes a matter of designing dimensioned routings from one point to another point with the branches, valves, piping specialties, and instrumentation as indicated on the P&ID. This statement, however, is an over simplification of the process, since many other factors must be considered, such as interference, piping flexibility, material costs, pipe supports, operation and maintenance, and safety and construction requirements.

8. Interferences

One of the most important aspects of piping layout is the avoidance of interferences with other facilities in the plant such as other piping systems; structural steel and concrete; heating, ventilating, and air-conditioning (HVAC) ductwork and electric cable trays and conduit. Once the designer is satisfied that the current system layout is interference-free, it will be added to the area composite drawing and the plastic model.

Specifically, three-dimensional (3D) computer modeling can provide an efficient, accurate, and cost-effective alternative to the traditional manual methods for interference detection.

9. Piping Flexibility

The effects of the thermal expansion of pipe and fittings as a result of system operating temperature changes cannot be overlooked during the layout and routing of any piping system. The function of piping flexibility or stress analysis has, for the most part, been delegated to the computer particularly in the case of high temperature, high-pressure piping systems. The piping stress analyst translates and enters the piping design data into the computer, reviews the output data, and if the system is too rigid, may suggest appropriate corrective redesigns. However, it is the piping designer's responsibility to ensure that the final stress analysis results are incorporated into the final pipe support and pipe routing design.

The piping designer should route piping with flexibility designed into it, using the minimum amount of pipe, fittings, and expansion loops by considering the following:

- Avoid the use of a straight run of pipe between two pieces of equipment or between two anchor points.
- A piping system between two anchor points in a single plane should, as a minimum, be L-shaped, consisting of two runs of pipe and a single elbow. This type of arrangement should be subjected to a "quick-check" analysis to determine if a formal computer stress analysis is required. A preferred solution in this case may be a series of two or more L-shaped runs of pipe.
- A piping system between two anchor points with the piping in two planes may consist of two L-shaped runs of pipe, e.g., one L-shaped run in the horizontal plane and another in the vertical plane. This arrangement should also be subjected to a quick-check analysis.
- A three-plane configuration may consist of a series of L-shaped runs and/or U shaped expansion loops designed into the normal routing of the system.
- When the expected thermal expansion in any given run of pipe is high, consider the use of an anchor at or near the center of the run, thereby distributing the expansion in two directions.
- For systems consisting of a large-diameter main and numerous smaller branch lines, the designer must ascertain that the branches are flexible enough to withstand the expansion in the main header.
- Systems which are to be purged by steam or hot gas must be reviewed to ensure that they will be flexible during the purging operation.

- System or equipment bypass lines may be cold due to lack of flow while the main runs are at operating design temperature, resulting in excessive stresses.
- Temperatures during initial start-up and testing are often greater than those at operating conditions.
- Closed relief valve and hot blow down systems should be given special attention due to rapid transients in temperature.

10. Valves

The piping designer must be familiar with proper application of all types of valves including gate, globe, plug, butterfly, ball, angle, diaphragm, check, pressure relief, and control valves and their methods of operation including manual, chain, gear, air, hydraulic, or motor. The following general guidelines should be applied when locating valves in any piping system:

- Valves should be installed with the stems between the vertically upward and horizontal positions with particular attention given to avoiding head and knee knockers, tripping hazards, and valve stems in the horizontal plane at eye level that may be a safety hazard. Large motor-operated valves should be installed in the vertical upright position where possible to facilitate support and maintenance.
- Valves in acid and caustic services should be located below the plant operator's eye level or in such a manner as to not present a safety hazard.
- The location of valves, with consideration for operating accessibility, should be accomplished in the natural routing of the system from point to point, avoiding the use of vertical loops and pockets.
- Valves in overhead piping with their stems in the horizontal position should be located such that the bottom of the hand wheel is not more than 6.5 ft (2 m) above the floor or platform. Only infrequently operated valves should be located above this elevation, and then the designer should consider the use of a chain operator or a platform for access.
- Where chain operators are used, the valves should be located such that the chain does not present a safety hazard to the operating personnel.
- A minimum of 4 in (100 mm) of knuckle clearance should be provided around all valve hand wheels.

- Valves should not be installed upside down.
- Space should be provided for the removal of all valve internals.

Improper application and placement of valves in the piping system can be detrimental to system function. This can result in malfunction of the valve and in water hammer, and this can cause the valves to literally self-destruct.

The following are some specific recommendations and methods of avoiding these problems for some specific types of valves.

10 – i. Control Valves

All control valve stations should be designed with the valve stem in the vertical upright position and a minimum of three diameters of straight pipe both upstream and downstream of the control valve, in order to reduce the turbulence entering and leaving the valve and to provide space for removal of the flange studs or bolts. Where applicable, this straight pipe will include the usual reduction in pipe size required to match the control valve size. Space must be provided for flange stud bolt removal where control valve bodies are designed for through bolt installation.

10 - ii. Butterfly Valves

Butterfly valves should be provided with a minimum of five diameters of straight pipe upstream of the valve; and if this requirement has been met, the valve stem and operator may be oriented in the position best suited for operation and maintenance. When a butterfly valve is preceded by an elbow and this straight-pipe requirement cannot be met, the valve stem must be oriented in the same plane as the elbow. That is, if the elbow is in the vertical plane, the valve stem must also be in the vertical plane. This recommendation is based on the fact that the velocity profile of the discharge of an elbow is not symmetric. The result can be fluid dynamic torque that is twice the magnitude of that found for a valve with a straight run of pipe upstream. The resultant eccentric forces applied to valve disk produces excessive vibration and disk flutter which eventually may completely destroy the valve.

10 – iii. Check Valves

The preferred installation of any check valve is in a horizontal, continuously flooded run of pipe with cap up; however, swing check valves will function properly in vertical runs of pipe with the flow up. However, the velocity and the rate of flow must be adequate to move the valve disk away from the seat and to maintain the valve in the open position, as required.

Experience has indicated that check valves are highly susceptible to chattering due to upstream turbulence caused by elbows and branches. Therefore the designer should provide upstream straight pipe in accordance with the valve manufacturer's recommendations. However, where this information is not available, the preliminary design should include a minimum of five diameters of straight pipe upstream of all check valves. In addition, the designer should be aware that this requirement can be as much as 10 diameters of straight pipe depending on the type of valve and the manufacturer.

10 – iv. Safety Relief Valves

The arrangement for installation of safety and relief valves is very critical and involves the actual location of the valve itself, the design of the vent stack, and the design of any associated drain piping. The designer should adhere to the valve manufacturer's recommendations

10 – v. Valve Location

- All relief valves must be in the vertical upright position and fitting-bound to the top of a horizontal run of pipe, the pressure source, and must not be located less than one nominal header diameter from any butt weld.
- A safety valve inlet connection in a high-velocity steam line should be located at least 8 to 10 nominal header diameters downstream of any bend in the header, to minimize the possibility of acoustically induced vibrations. In addition, it should be at least 8 to 10 nominal header diameters either upstream or downstream of any diverging or converging T or Y fitting.
- No other header branch penetration, for any purpose, should be made in the same circumferential cross section containing the safety valve inlet nozzle.

- Where more than one safety valve or a service branch is to be installed in the same header run, a minimum distance of 24 in (600 mm) or 3 times the sum of the nozzle inside radii, whichever is greater, shall be provided between the nozzles.
- Where more than two safety valves are located in the same header run, the spacing between valves should be varied such that the distance between two adjacent valves differs by at least an inlet nozzle diameter.

11. Pipe Racks

Pipe racks are structures designed and built specifically to support multiple pipes where adequate structure is not available. Pipe layout on pipe racks should follow the Pipe Planning Study concepts. Avoid designing one pipe at a time in order to avoid unnecessary overcrowding and fittings for pipes to enter and depart from the rack. Where possible, pipes should rest directly on the rack with the use of insulation, if required. Steam piping should exit the rack with a vertical up-and over to avoid condensate collection points, while water piping should exit the rack with a vertical down-and-under to avoid a high-point air pocket collection point.

12. Insulation

The piping designer should be familiar with these requirements and specifically with the thickness of insulation for any given system. In the location and spacing of piping systems, there must be clearance space between the insulation of one pipe and any adjacent pipe and/or other possible interference such as structural steel. The piping designer should also recognize that in some applications insulation may not be required for the prevention of heat loss but will be needed for personnel protection and the spacing and clearances should be adjusted accordingly.

13. Pipe Supports

Pipe supports require structural support, which means that piping should be located in close proximity to steel or concrete. Do not locate the pipe too close to the structure, so as to allow adequate space for the pipe support hardware to facilitate installation. Additionally the pipe insulation needs to be considered for clearances and insulation saddles. The most preferred location is either resting directly on structural steel for bottom support or using a single rod to the structure directly above the pipe.

14. Operability, Maintenance, Safety, and Accessibility

Operability, maintenance, safety, and accessibility are interdependent, and certainly if any given piping component is accessible, it is also assumed to be operable and maintainable. However, maintenance may require additional space for dismantling the component. It is the responsibility of the piping designer to design a piping arrangement that satisfies all these (and other) requirements with the lowest total cost, i.e., resulting in the shortest pipe runs and the fewest fittings and pipe supports.

14 - i. Operability

From the standpoint of operating personnel, operability means being able to perform daily functions in an efficient manner. This is done with consideration for the frequency of operation and the degree of physical effort required to performing it. The designer cannot make every valve and instrument ideally accessible, but will concentrate on those requiring the most frequent operation. Safety-related equipment and valves that are required to be operated during an emergency or to perform critical system functions must be accessible without exception.

To ensure success, the designer, system engineer, and operating personnel work out the final arrangement. In difficult cases, models or even full-size mock-ups have been used as design aids. In general, an operable valve or instrument is one that can be readily reached when standing at grade or on an elevated floor or platform provided for that purpose. The position of the valve hand wheel should be such that the force necessary to operate it can be applied without strain or undue contortions or interference from valves, lines, or other equipment. It is recognized that plant operating personnel will occasionally have to reach for a drain from a kneeling position or a vent valve from a ladder, but these are infrequent operations and as such can be tolerated.

14 – ii. Maintenance

Ease of maintenance actually begins with the development of the plant arrangement and equipment locations by providing sufficient space around each piece of equipment not only for the maintenance of the machinery alone but also for the pipe and the maintenance of the related components. These space allocations should include the pull spaces, lay down spaces, and rotor and tube removal spaces for the dismantling of all pieces of equipment. The engineering of the system P&IDs will indicate the need for maintenance facilities in the form of bypasses and block valves that would permit certain pieces of equipment or components to be worked on while the system is operating, or at least with a minimum of downtime. The designer has to design these facilities into the system and to provide the accessibility necessary to accomplish that maintenance, including the provision for any lifting gear such as cranes, davits, monorails, and hoists.

14 – iii. Safety and Accessibility

Stairs, platforms, ladders, aisles, means-of-egress aisle ways, and minimum headroom allowances designed in accordance with OSHA will provide a safe place to work. It is the responsibility of the piping designer to place equipment, valves, and other piping components in such positions that they do not create hazards. These hazards could include any piping components that presented themselves as "head knockers," "knee knockers," or trippers.

The most common cause of these problems is valve stems, and common sense would say to place a valve in a horizontal run of pipe with the stem vertical, wherever possible. When this cannot be done, the designer should ascertain that the stem does not project into an access area and become a hazard. The designer should make every effort to keep such projections out of heights of 4 1/2 to 6 ft (1.5 to 2 m), or specifically at face level.

Steam system valves must not be placed at face level in the horizontal position since a packing gland leak may blow steam into the face of an operator; if this were a superheated steam leak, the vapor would not be visible. This same principle applies to hazardous and toxic fluids. However, this may be too restrictive, and it is not meant to rule out any perfectly safe arrangement of valves at face level if

- They are outside the limit of a platform.
- They are a part of a manifold of valves, all projecting about the same distance and with adequate access space in front of them.
- It is an isolated valve guarded by an adjacent pipe or structural steel.

The designer should review the layout and determine if there is a need for any platforms which access a remotely located valve or component.

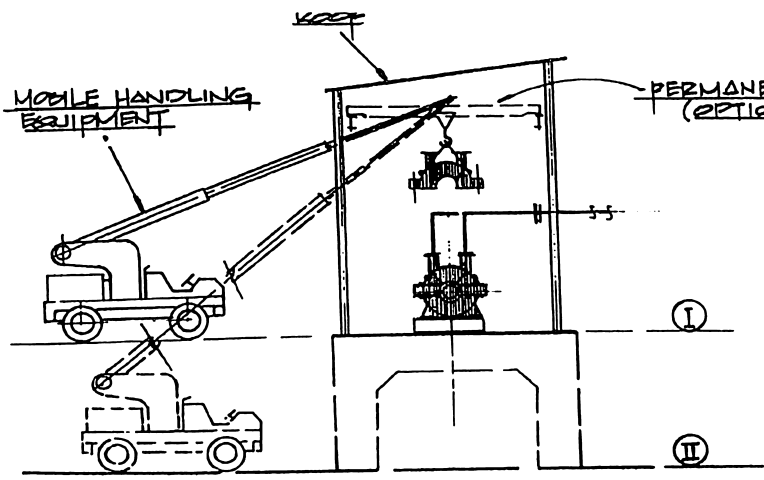


Figure 03 – Compressor Handling

15. Interfacing Disciplines and Organizations

Piping design requires coordination and cooperation with all interfacing disciplines including civil, electrical, instrumentation, and construction. Piping arrangements should blend with the layout design of interfacing disciplines. Pipes that require extensive support schemes in lieu of being conveniently located near structural support steel should be avoided. Pipes or electrical trays that twist and turn to avoid one another should be uniformly designed in a coordinated design effort which reduces congestion and reduces TIC. Most piping designs are not completed by a single designer or company, which makes the coordination between designers and different organizations critical. The best way to address this concern is to agree to specific divisions of responsibility in the planning phase of the project.

3.13 APPLICATION OF COMPUTER-AIDED DESIGN TO PIPING LAYOUT

The piping industry today is very diverse in its use of computer-aided design. This diversity is shown by the various levels of sophistication of the CAD applications in use by different segments of the industry. Even within the same company, the sophistication of CAD use can vary widely from discipline to discipline, department to department. This diversity ranges from a surprisingly large portion of the industry in which there is little use of CAD to a few who claim to be approaching a paperless office. Between these two extremes, most of the industry appears to be using CAD as computer-aided drafting. In this sense, CAD becomes an electronic pencil, not necessarily a design tool.

3.14 STRESS ANALYSIS

After piping materials, design pressure and sizes have been selected, a stress analysis is performed that relates the selected piping system to the piping layout and piping supports.

The analysis ensures that the piping system meets intended service and loading condition requirements while optimizing the layout and support design. The analysis may result in successive reiterations until a balance is struck between stresses and layout efficiency, and stresses and support upon system complexity and the design code.

ASME B31.3 requires the analysis of three stress limits

- Stresses due to sustained loads
- Stresses due to displacement strains
- Stresses due to occasional loads

3.14.1 STRESSES DUE TO SUSTAINED LOADS

The stress analysis for sustained loads includes internal pressure stresses, external pressure stresses and longitudinal stresses. ASME B31.3 considers stresses due to internal and external pressures to be safe if the wall thickness meets the pressure integrity requirements. The sum of the longitudinal stresses in the piping system that result from pressure, weight and any other sustained loads do not exceed the basic allowable stress at the maximum metal temperature.

$S_L < S_h$

Where, S_L – Longitudinal stress, MPa (psi)

S_h – Basic allowable stress at maximum material temperature, MPa (psi)

The internal pressure in piping normally produces stresses in the pipe wall because the pressure forces are offset by pipe wall tension. The exception is pressure transients such as water hammer which add load to pipe supports.
The longitudinal stress from pressure is calculated by

$S_L = P^* D_O / [4^*t]$

Where, D_O – Pipeline Outer diameter inch

t – Thickness of line pipe in inch

P – Pressure (design) at any section Pisa

S_L – Longitudinal stress, MPa (psi)

The longitudinal stress due to weight is dependent upon support locations and pipe span. The formula to calculate the pipe stress is

$S_L = 0.1^*[W^*L^2/n^*Z]$

Where, S_L – Longitudinal stress, MPa (psi)

W – Distributed weight of pipe material, contents and insulation, N/m (lbs/ft)

n – Conversion factor, 10^{-3} m/mm (1 ft/12 in)

Z – Pipe section modulus, mm^3 (in^3)

L – Pipe span, m (ft)

$Z = 3.14/32^* \{[D_o^4 - D_i^4]/D_o\}$

Where, D_O – Pipeline Outer diameter inch

D_i – Pipeline inner diameter inch

3.14.2 STRESSES DUE TO DISPLACEMENT STRAINS

Constraint of piping displacements resulting from thermal expansion, seismic activities or piping support and terminal movements cause local stress conditions. These localized conditions can cause failure of piping or supports from fatigue or over-stress, leakage at joints or distortions. To ensure that piping systems have sufficient flexibility to prevent these failures, ASME B31.3 requires that the displacement stress range does not exceed the allowable displacement stress range.

$S_E < S_A$

Where, S_E – Displacement stress range, MPa (psi)

S_A – Allowable displacement stress range, MPa (psi)

$S_A = f*[1.25* (S_C+S_h) - S_L\}]$

Where, f – Stress reduction factor

Sc – Basic allowable stress of minimum material temperature, MPa (psi),

S_h – Basic allowable stress at maximum material temperature, MPa (psi)

$f = 6.0*[N]^{-0.2} <= 1$

Where, N – Equivalent number of full displacement cycles during the expected service life, $< 2 \times 10^6$

$S_E = [S_b^2 + 4S_t^2]^{0.5}$

Where, S_E – Displacement stress range, MPa (psi)

S_b – Resultant bending stress, MPa (psi)

S_t – Torsional stress, MPa (psi)

$S_b = [(i_iM_i)^2 - (i_oM_o)^2]^{0.5}/(n*Z)$

Where, S_b – Resultant bending stress, MPa (psi)

i_i – In plane stress intensity factor

M_i – In plane bending moment, N-m (lb-ft)

i_o – Out plane stress intensity factor

M_o – Out plane bending moment, N-m (lb-ft)

n – Conversion factor, 10^{-3} m/mm (1 ft/12 in)

Z – Pipe section modulus, mm (in)

$S_t = M_t / [2*Z*n]$

Where, S_t – Torsional stress, MPa (psi)

M_t – Torsional moment, N-m (lb-ft)

n – Conversion factor, 10^{-3} m/mm (1 ft/12 in)

Z – Pipe section modulus, mm (in)

A formal flexibility analysis is not required when the new piping system replaces in kind, or without significant change, a system with a successful service record the new piping system can be readily judged adequate by comparison to previously analyzed systems and the new piping system is of uniform size, has 2 or less fixed has no intermediate restraints, and meets the following empirical condition

$[D_o * Y] / [L - L_s]^2 * K_1$

Where, D_o – Pipeline Outer diameter inch

L – Length of the Pipeline between anchors, m (ft)

Y – Resultant of total displacement strains, mm (in)

L_s – Straight line distance between anchors, m (ft)

K_1 – Constant, 208.3 for SI units

3.14.3 STRESSES DUE TO OCCASIONAL LOADS

The sum of the longitudinal stresses due to both sustained and occasional loads does not exceed 1.33 times the basic allowable stress at maximum material temperature.

$S_L = 1.33*S_h$

Where, S_h – Basic allowable stress at maximum material temperature, MPa (psi)

S_L – Longitudinal stress from sustained and occasional loads, MPa (psi)

The occasional loads that are analyzed include seismic, wind, snow and ice, and dynamic loads. Seismic and wind loads do not have to be considered as acting standards. Stress analysis has been carried out by means of CAESAR II software.

4. COMPUTATIONS

4.1 DESIGN BASIS

Throughput	= 16.68 MSCMD
Length Of pipeline	= 10 Km
Supply Pressure	= 171.39 psia
Supply Temperature	= 27^{0}C
Receiving Terminal Pressure	= 213.35 – 227.57 psia [Minimum]
Design Pressure	= 300 psia = MAOP
Fluid Name	= Propylene Gas

GAS COMPOSITION

Component	Mole %
C_3H_6	99.55
C_2H_6	0.02
C_3H_8	0.43
Total	100

Table 04 – Gas Composition

GRADE OF LINE PIPE

XS

DESIGN CACULATIONS

4.2 PIPELINE SIZING

Pipe Diameter [Di] = {1.44 *10^{-3} *[Q_b *Z*T_f / P * u]} ^ 0.5

= {1.44 *10^{-3} *[24543695.7 * 0.786 * 540.27 / 298.2635 * 59.9311]} ^ 0.5

Pipe Diameter [Di] = 28.9762 inch

4.3 EROSIONAL VELOCITY

Erosional velocity [ue] = 100/[29*G*P/Z*R*T]^0.5

= 100/[29*0.69*229.2362/0.786*10.73*540.27]^0.5

Erosional velocity [ue] = 99.5810ft/sec

The recommended value for the gas velocity for the gas pipelines is 40 – 50 % of the Erosional velocity or for 50- 60 % of the Erosional velocity for non major mainlines [i.e. 15-17 m/s]

Operating velocity [u] = Erosional velocity [ue] * 0.6

= 99.5817*0.6

Operating velocity [u] = 59.7486 ft/sec

4.4 OPERATING VELOCITY

Operating velocity [u] = $1.44 * 10^{-3} * [Q_b * Z * T_f / P * Di^2]$

= $1.44 * 10^{-3} * [24543695.7 * 0.786 * 540.27 / 298.2635 * 28.9762^2]$

Operating velocity [u] = 59.9311 ft/sec

4.5 REYNOLDS NUMBER

The Reynolds number can be used to check the flow regime of the gas transmission pipeline

$Re = [45 * Q_b * G] / D_i$

= [45*2.454369*10^7*0.69]/28.9765

Re = 26299987

The calculated value of the pipeline is much more than 4000 so the flow is fully turbulent.

4.6 TRANSMISSION FACTOR

The transmission factor for fully turbulent flow is given by Nikuradse equation as

$[1/f]^{0.5} = 4 * \log [3.7 * Di / Ke]$

$[1/f]^{0.5} = 4 * \log [3.7 * 28.9765 / 0.0007]$

$[1/f]^{0.5} = 20.74$

4.7 PRESSURE CALCULATION

Panhandle A Equation

$P_1^2 - P_2^2 = K_1 Q_b^n$

$R = 2.552 * 10^{-4} * T_f * Zavg * [G^{0.855} / Di^{4.856}]$

n = 1.855

$K_1 = R * L$

$K_1 = 2.552 * 10^{-4} * 540.27 * 0.786 * [0.69^{0.855} / 28.9763^{4.856}] * 32808.34$

= 0.000262

$298.2635^2 - P_2^2$ = $0.000262 * 24540.45^{4.856}$

P_2^2 = 52549.2178

P_2 = 229.2361 psia

4.8 COMPRESSOR CALCUATIONS

4.8.1 COMPRESSION RATIO

Generally the compression ratio is limited to 1.2 to 1.8 for centrifugal compressors

Compression Ratio = Discharge Pressure/Suction Pressure

= 298.26/171.39

= 1.74

4.8.2 ADIABATIC EFFICIENCY

Adiabatic Efficiency [η_a] = $(T_1/ T_2 - T_1)*(Z_1/Z_2/)*\{(P_2/P_1) \wedge (\gamma - 1/ \gamma)-1\}$

= $(540.27/ 709.47 - 540.27)*(0.786/0.72)* \{(298.26/171.39) \wedge (1.371 - 1/ 1.371)-1\}$

η_a = 0.7982

4.8.3 HORSEPOWER REQUIRED

From the energy input to the gas, following equation is used to calculate the compressor HP

HP = $4.0639*(\gamma/ \gamma - 1)*Q*(Z_1+Z_2/2)*T_1*(1/ \eta a)*\{(P_2/P_1) \wedge (\gamma - 1/ \gamma)-1\}$

= $4.0639*(1.371/ 1.371 - 1)*16.68*(0.786+0.72/2)*300*(1/ .7982)* \{(298.26/171.39) \wedge (1.371 - 1/ 1.371)-1\}$

HP = 15978.76 kW

4.8.4 BRAKE HORSEPOWER (BHP)

Brake Horsepower (BHP) required may be calculated as follows

BHP = HP/η_m

= 15978.76/0.98

BHP = 16819.75 kW

4.8.5 OVERALL EFFICIENCY

Overall efficiency [η_o] = $\eta_a * \eta_m$

= 0.7982*0.98

η_o = 0.7822

4.9 STRENGTH OF PIPE

4.9.1 HOOP STRESS

Hoop stress S_H = [P* D]/ [2*t]

= [300*30]/ [2*0.511]

S_H = 8806.26 psia

4.9.2 LONGITUDINAL STRESS

Longitudinal stress S_L = [P* D]/ [4*t]

= [300*30]/ [4*0.511]

S_L = 4403.13 psia

4.10 THICKNESS CALCULATION

Considering the Location Class 2, Electric resistance welded pipe, and the temperature below 121 ^{o}C

F = 0.60

E = 1.00

T = 1.00

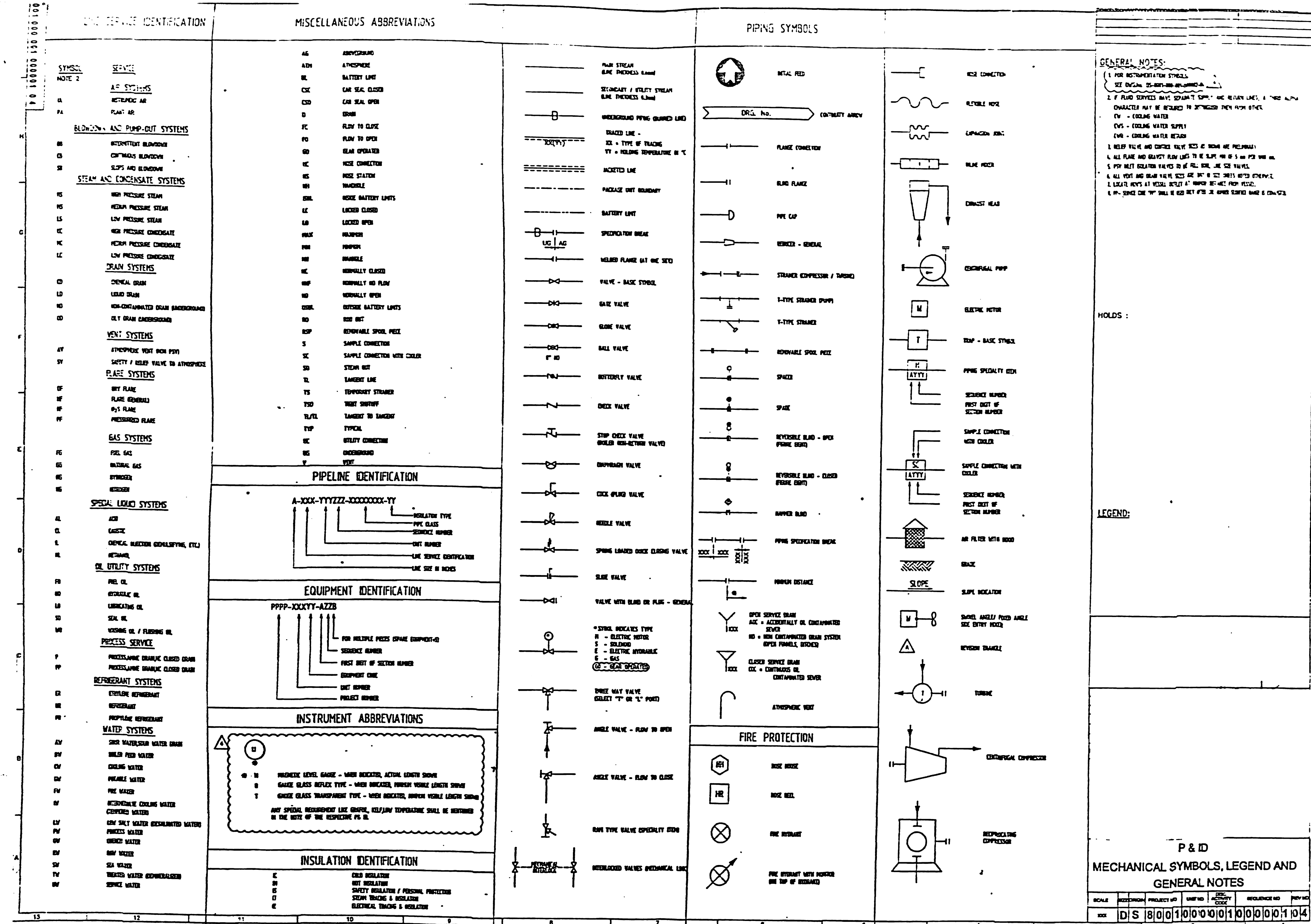
Case: 30 inch, XS Grade pipe

Thickness [t] = [P* D]/ [2*S*F*E*T]

= [300*30]/[2*14600*0.60*1.00*1.00]

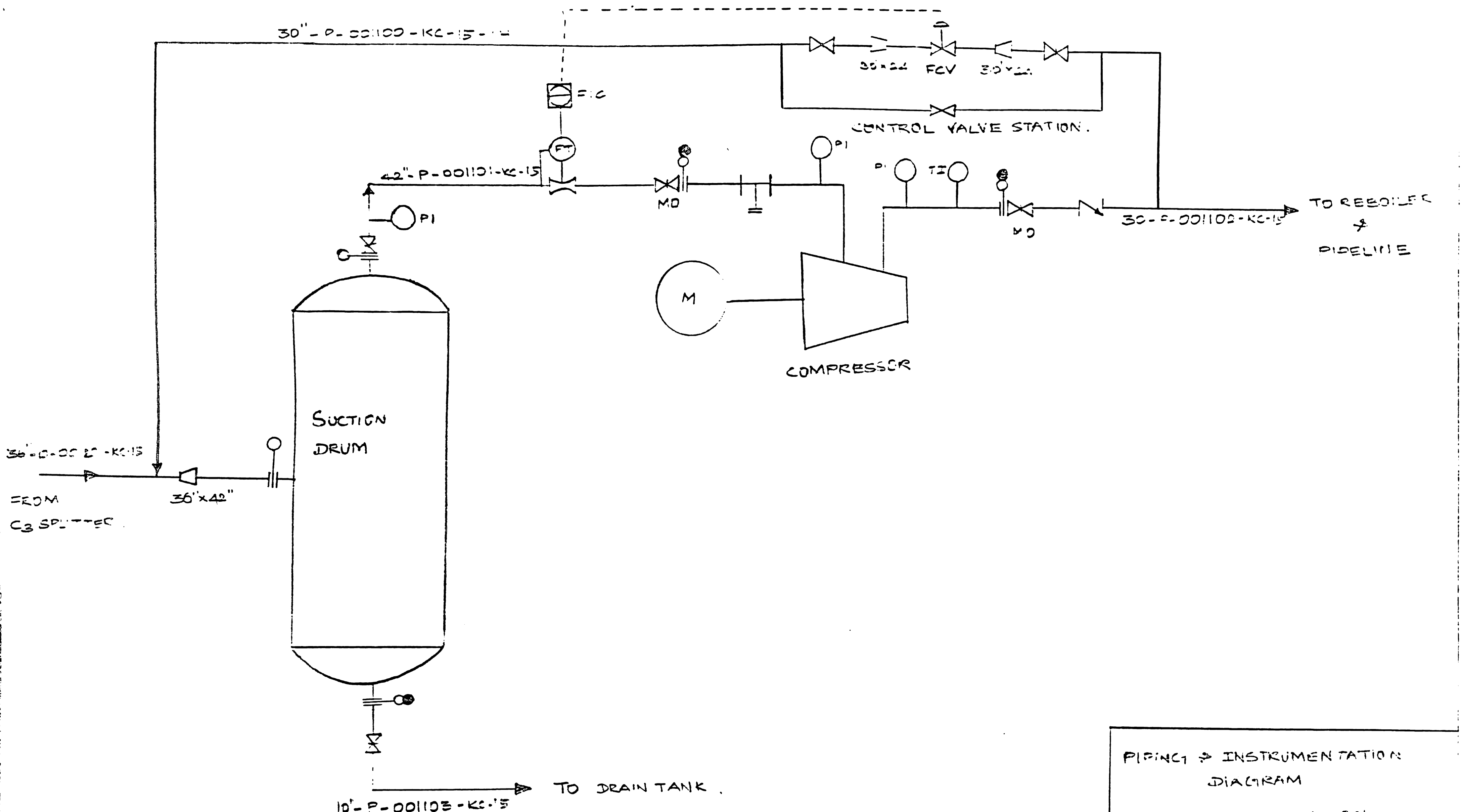
Thickness [t] = 0.511 inch – Calculated

4.11 PROCESS & INSTRUMENTATION DIAGRAM LEGEND



LINE SERVICE IDENTIFICATION
MISCELLANEOUS ABBREVIATIONS
PIPING SYMBOLS
GENERAL NOTES:
HOLDS :
LEGEND:
SYMBOL NOTE 2
SERVICE
AIR SYSTEMS
BLOWDOWN AND PUMP-OUT SYSTEMS
STEAM AND CONDENSATE SYSTEMS
DRAIN SYSTEMS
VENT SYSTEMS
FLARE SYSTEMS
GAS SYSTEMS
SPECIAL LIQUID SYSTEMS
OIL UTILITY SYSTEMS
PROCESS SERVICE
REFRIGERANT SYSTEMS
WATER SYSTEMS
PIPELINE IDENTIFICATION
A-XXX-YYYZZZ-XXXXXXXX-YY
EQUIPMENT IDENTIFICATION
PPPP-XXXYY-AZZB
INSTRUMENT ABBREVIATIONS
INSULATION IDENTIFICATION
DRG. No.
UG | AG
SLOPE
FIRE PROTECTION
HR
P & ID
MECHANICAL SYMBOLS, LEGEND AND GENERAL NOTES
D S 8 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 4
A1 841x594

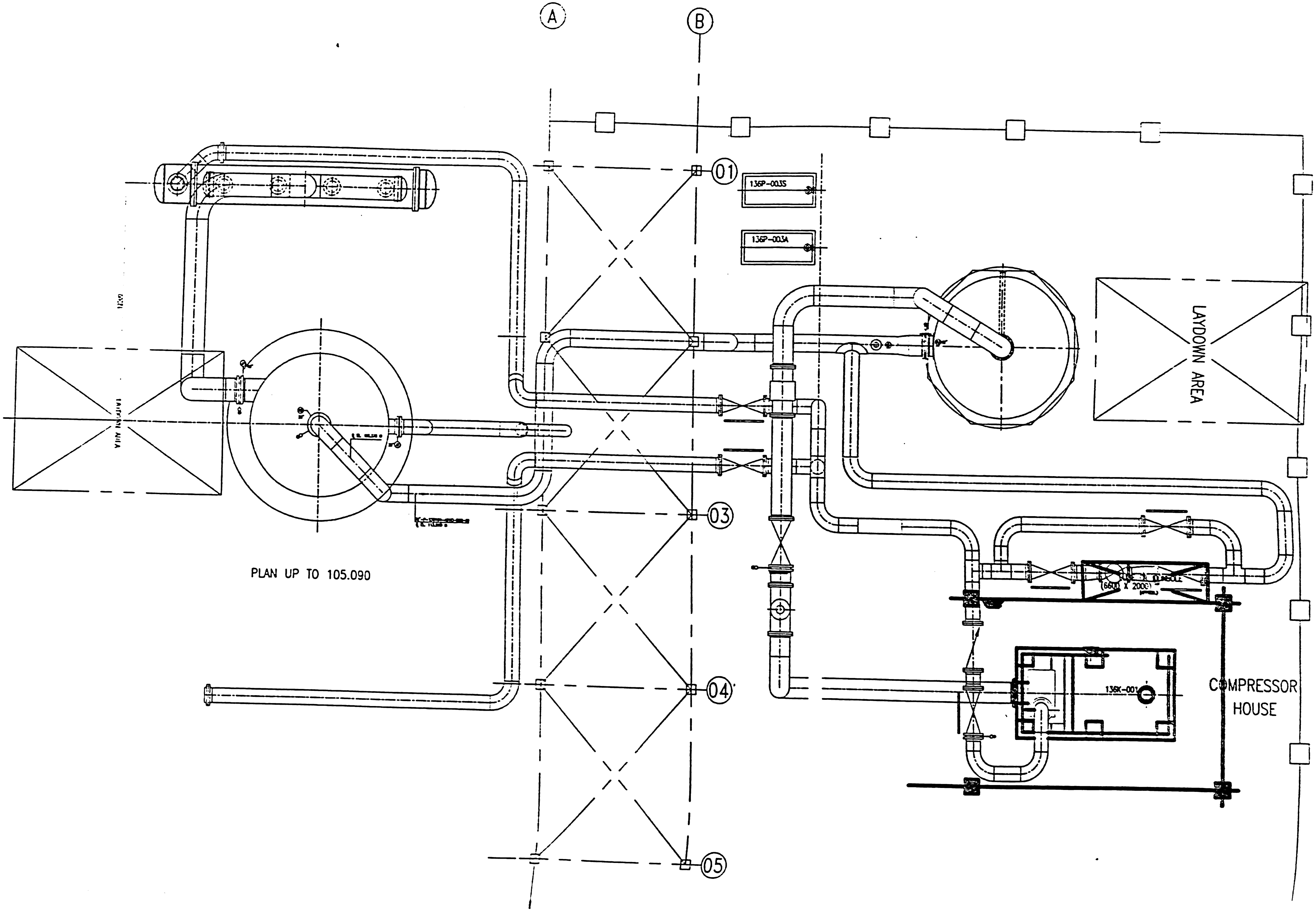
4.11 PROCESS & INSTRUMENTATION DIAGRAM FOR COMPRESSOR STATION



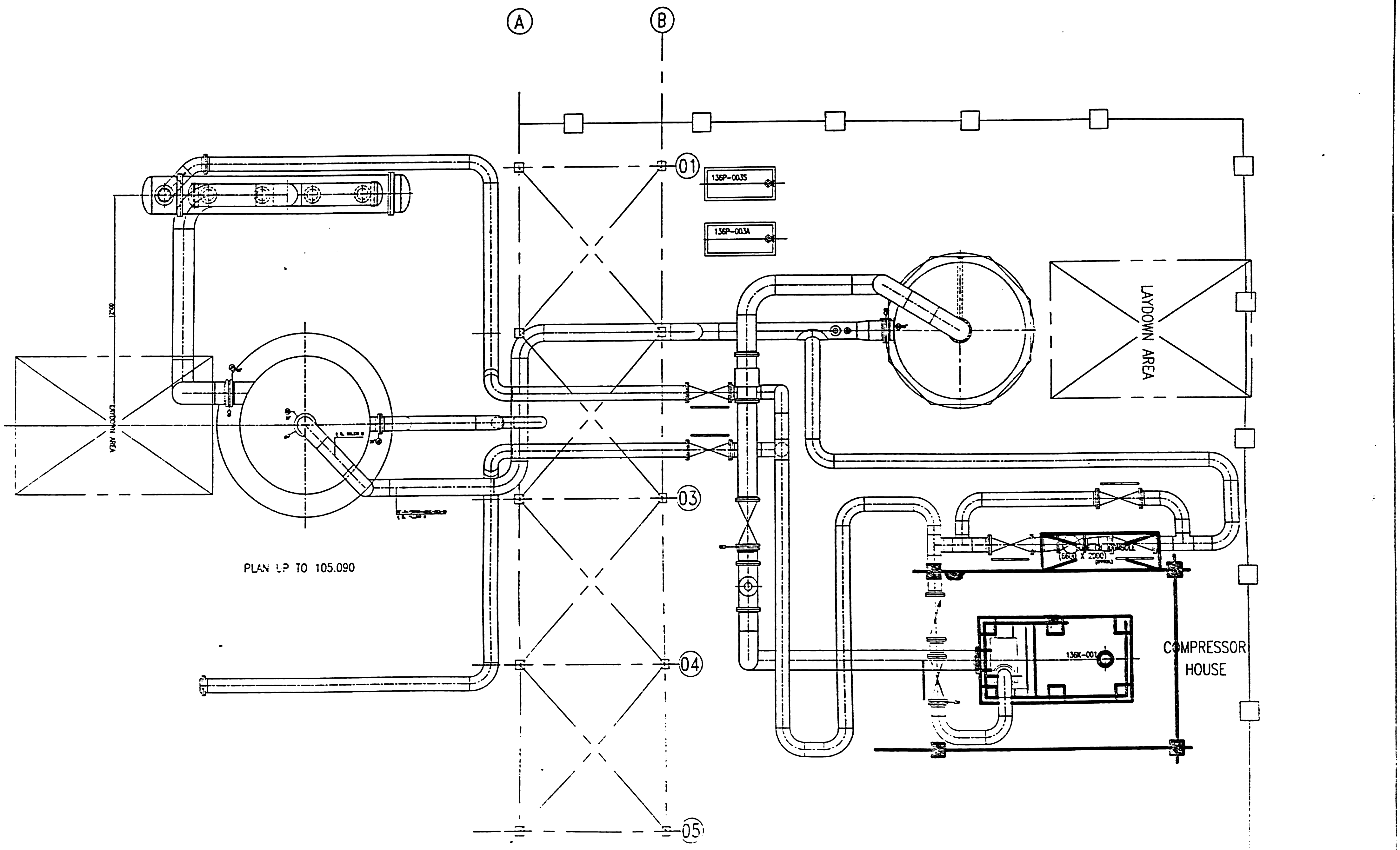
PIPING & INSTRUMENTATION DIAGRAM

COMPRESSOR STATION

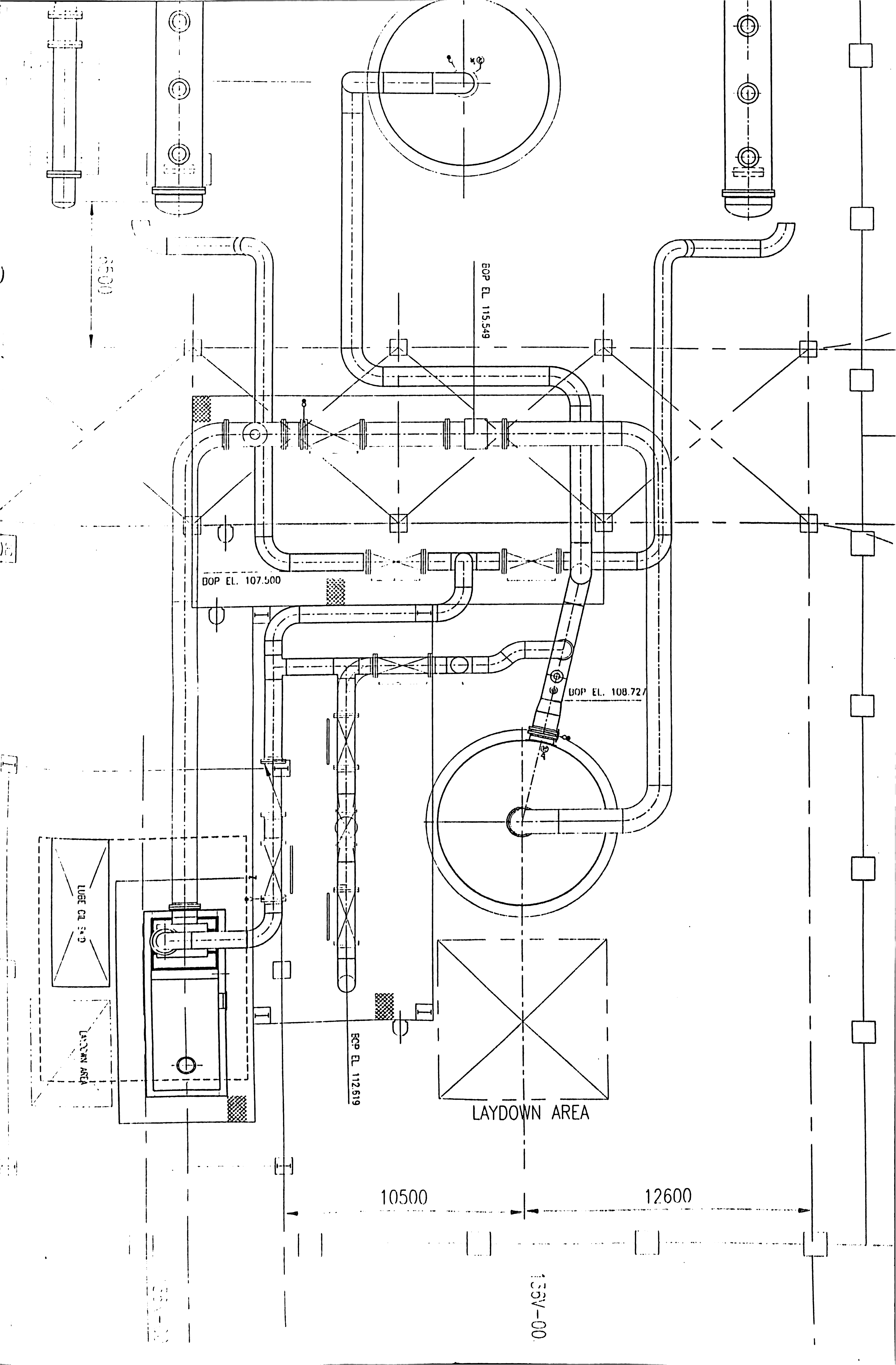
4.12 PIPING ROUTING LAYOUT FOR COMPRESSOR STATION - OPTION - 1


A
B
01
03
04
05
136P-003S
136P-003A
LAYDOWN AREA
136K-001
COMPRESSOR HOUSE
(6600 X 2000)
PLAN UP TO 105.090

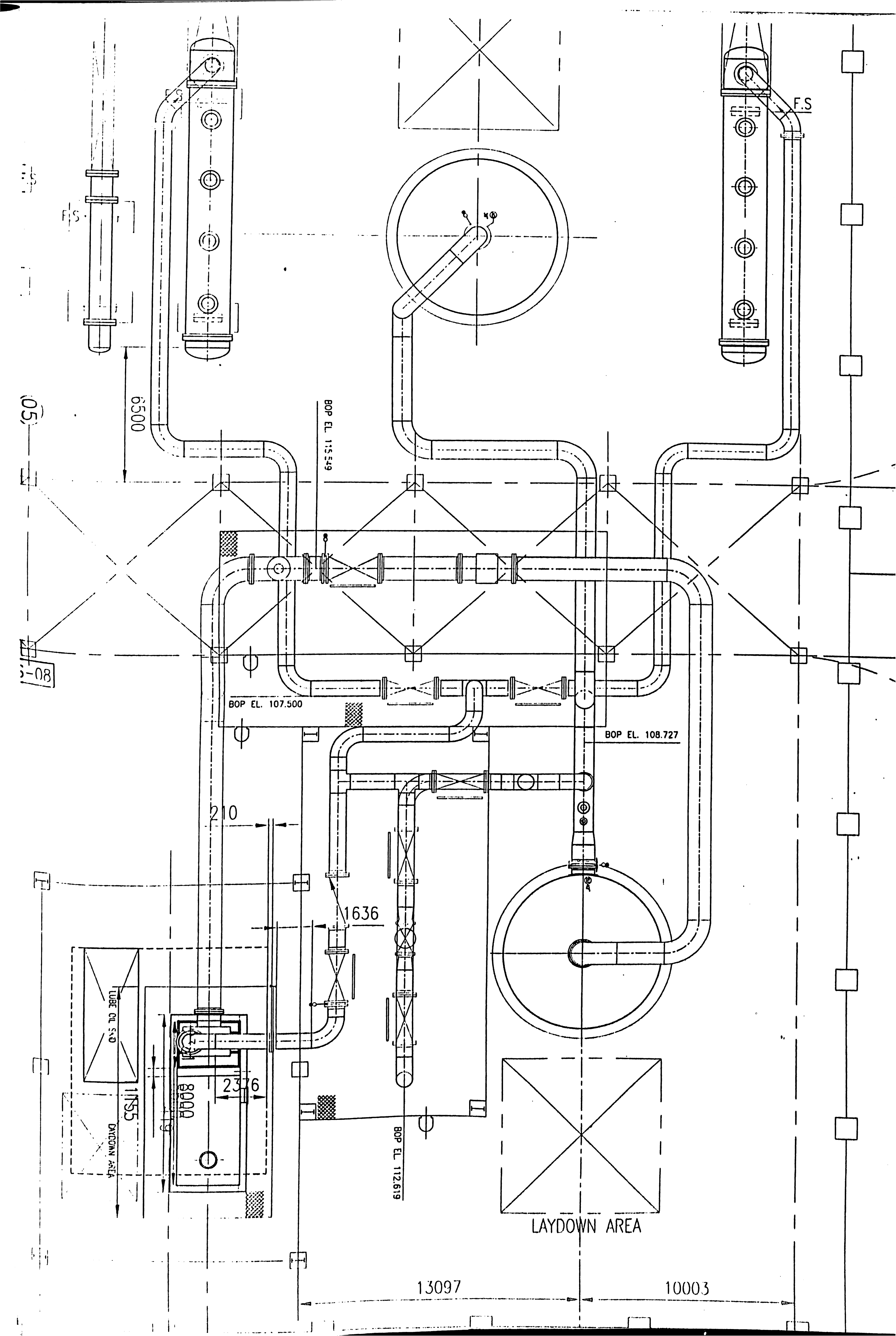
4.12 PIPING ROUTING LAYOUT FOR COMPRESSOR STATION - OPTION - 2


A
B
01
03
04
05
136P-003S
136P-003A
LAYDOWN AREA
LAYDOWN AREA
12500
PLAN LP TO 105.090
(6600 X 2000)
136K-001
COMPRESSOR
HOUSE

4.12 PIPING ROUTING LAYOUT FOR COMPRESSOR STATION - OPTION - 3

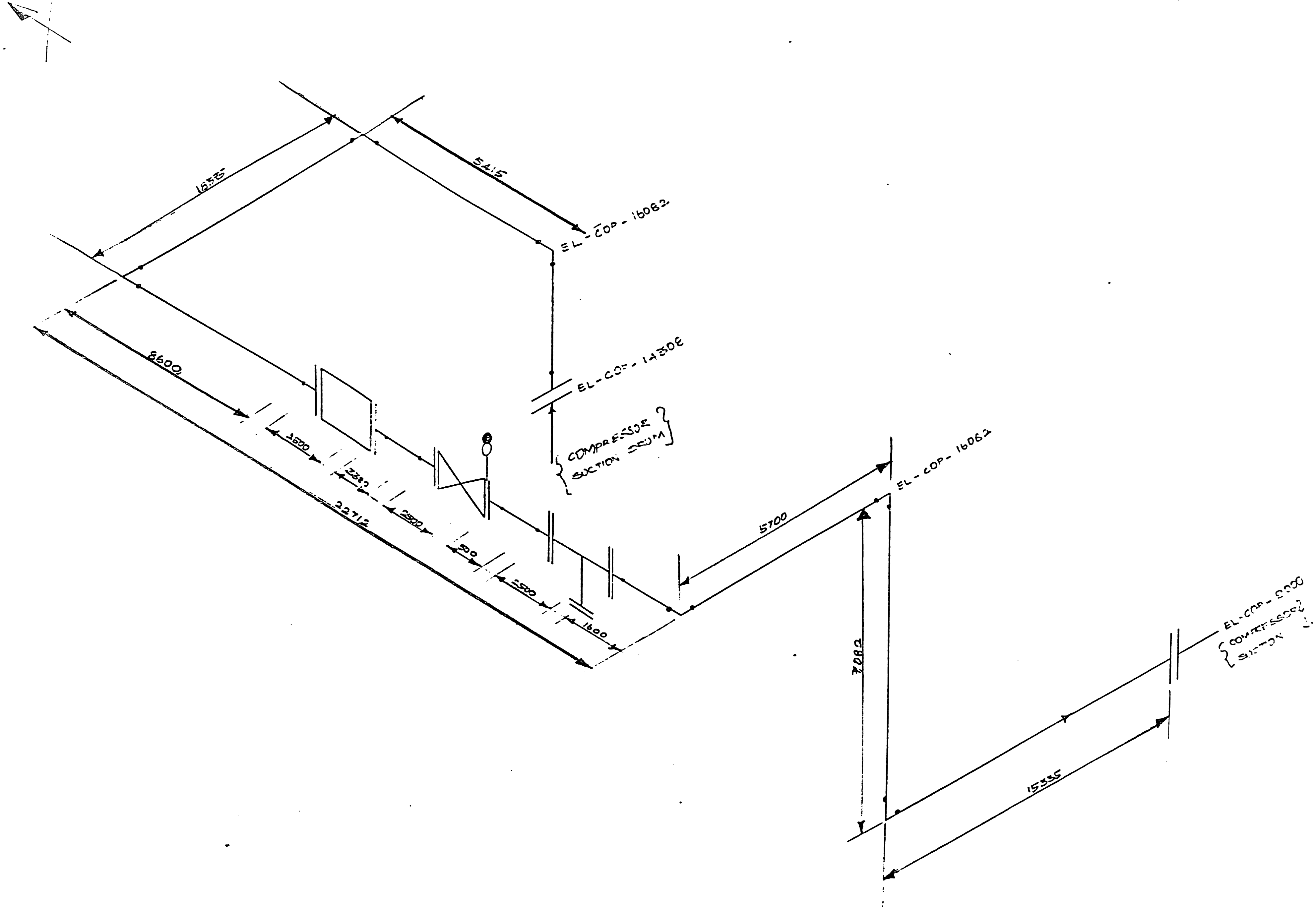

BOP EL. 115.549
BOP EL. 107.500
BOP EL. 112.619
LAYDOWN AREA
LAYDOWN AREA
10500
12600

4.12 PIPING ROUTING LAYOUT FOR COMPRESSOR STATION – OPTION - 4 APPROVED FOR MODELING



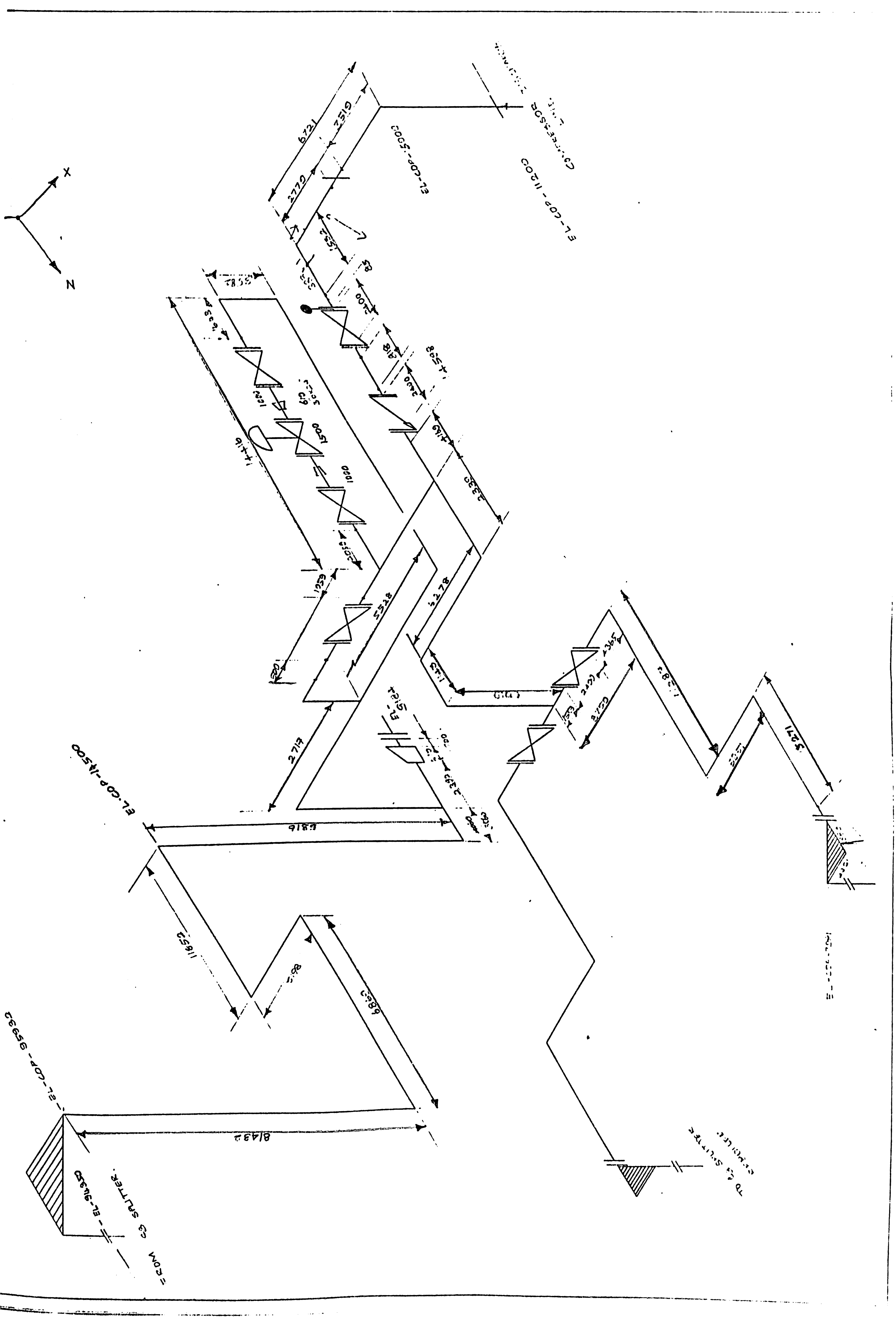
F.S
F.S
6500
BOP EL. 115.549
BOP EL. 107.500
BOP EL. 108.727
210
1636
LUBE OIL SKID
2376
8000
1155
LAYDOWN AREA
BOP EL. 112.619
LAYDOWN AREA
13097
10003

4.13 ISOMETRIC DRAWING FOR COMPRESSOR SUCTION LINE



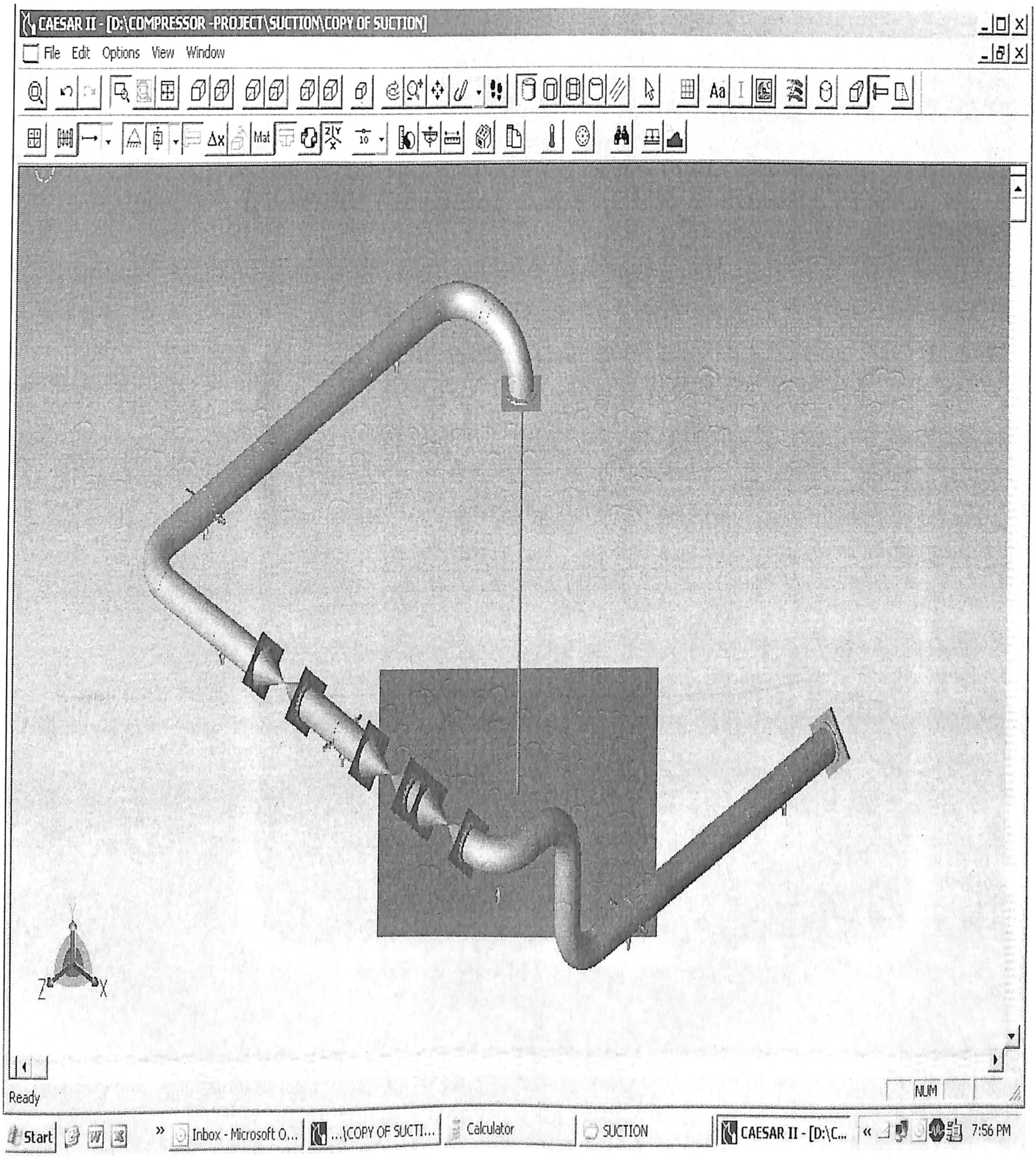
15335
5415
EL-COP-16062
8600
EL-COP-14308
COMPRESSOR SUCTION DRUM
3500
2380
2500
22712
500
2500
1600
5700
EL-COP-16062
7082
15335
EL-COP-9000
COMPRESSOR SUCTION

4.13 ISOMETRIC DRAWING FOR COMPRESSOR DISCHARGE LINE



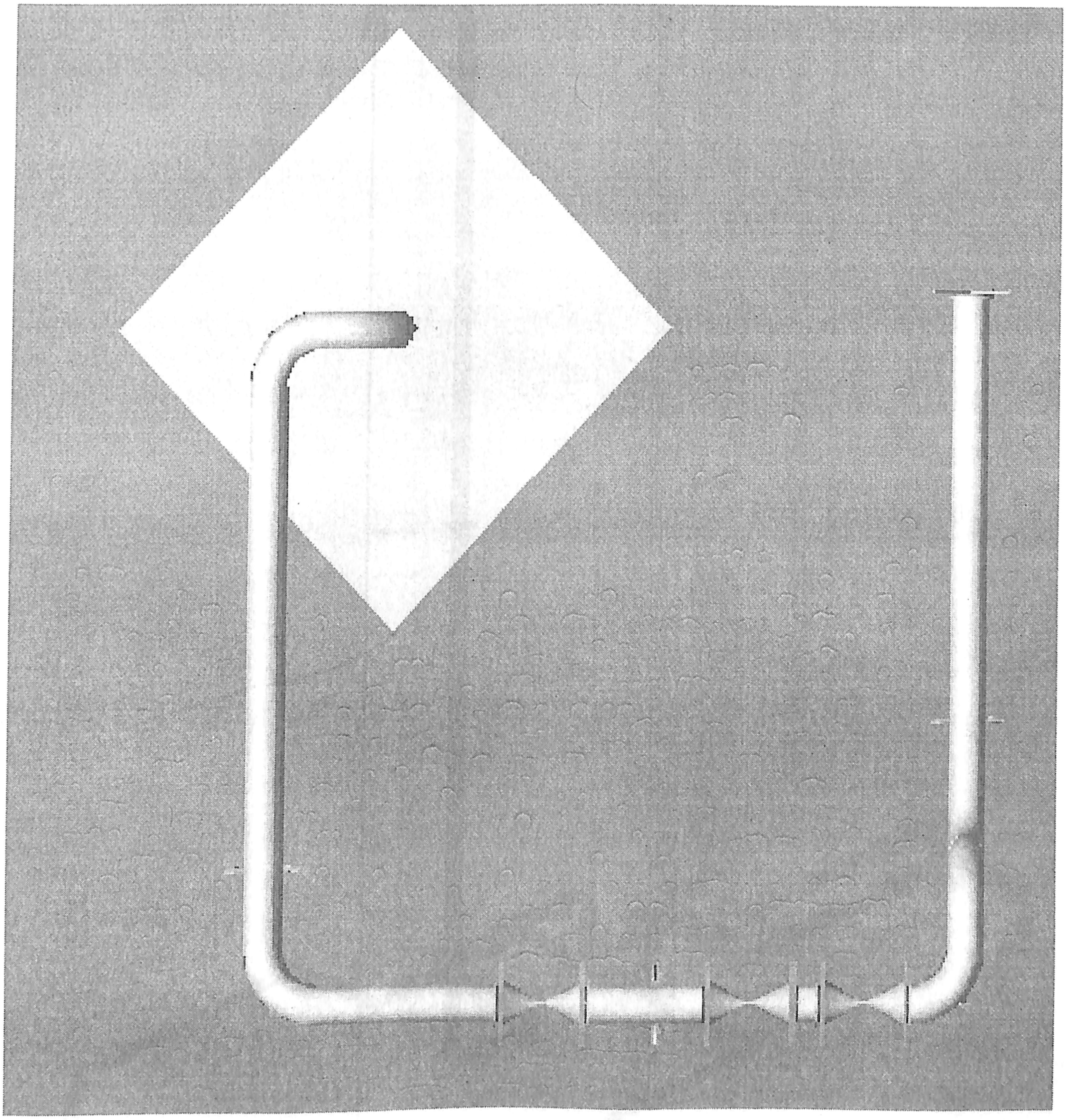
X
N
EL-COP-11200
EL-COP-5000
EL.COP-14500
FROM C3 SPLITTER.
6721
2779
2519
6816
8432
11652
6989
5528
5278
2330
5271
2717

4.14 COMPRESSOR SUCTION LINE MODELING DIAGRAM IN CAESAR II ISOMETRIC VIEW

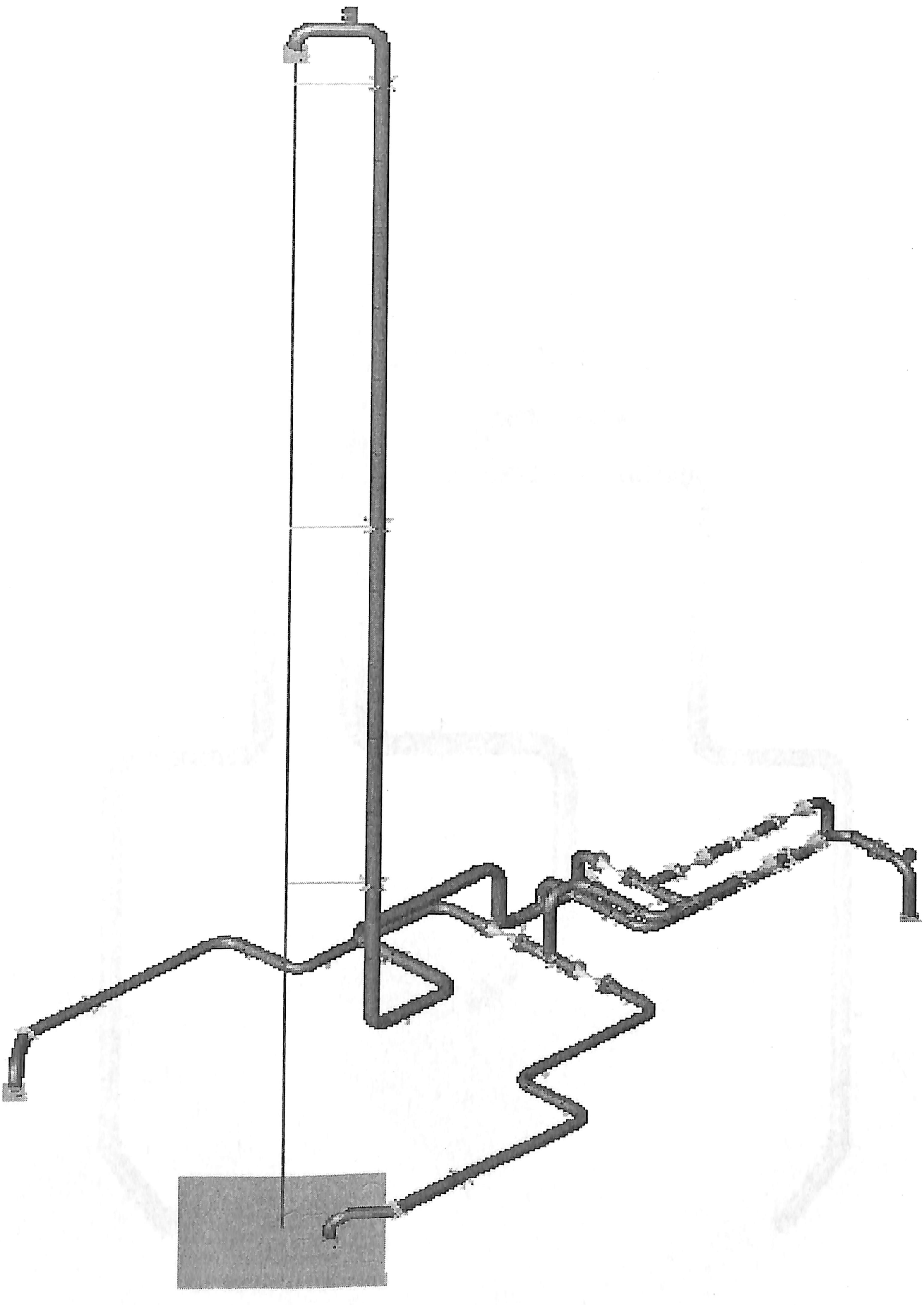


4.14 COMPRESSOR SUCTION LINE MODELING DIAGRAM IN CAESAR II

TOP VIEW

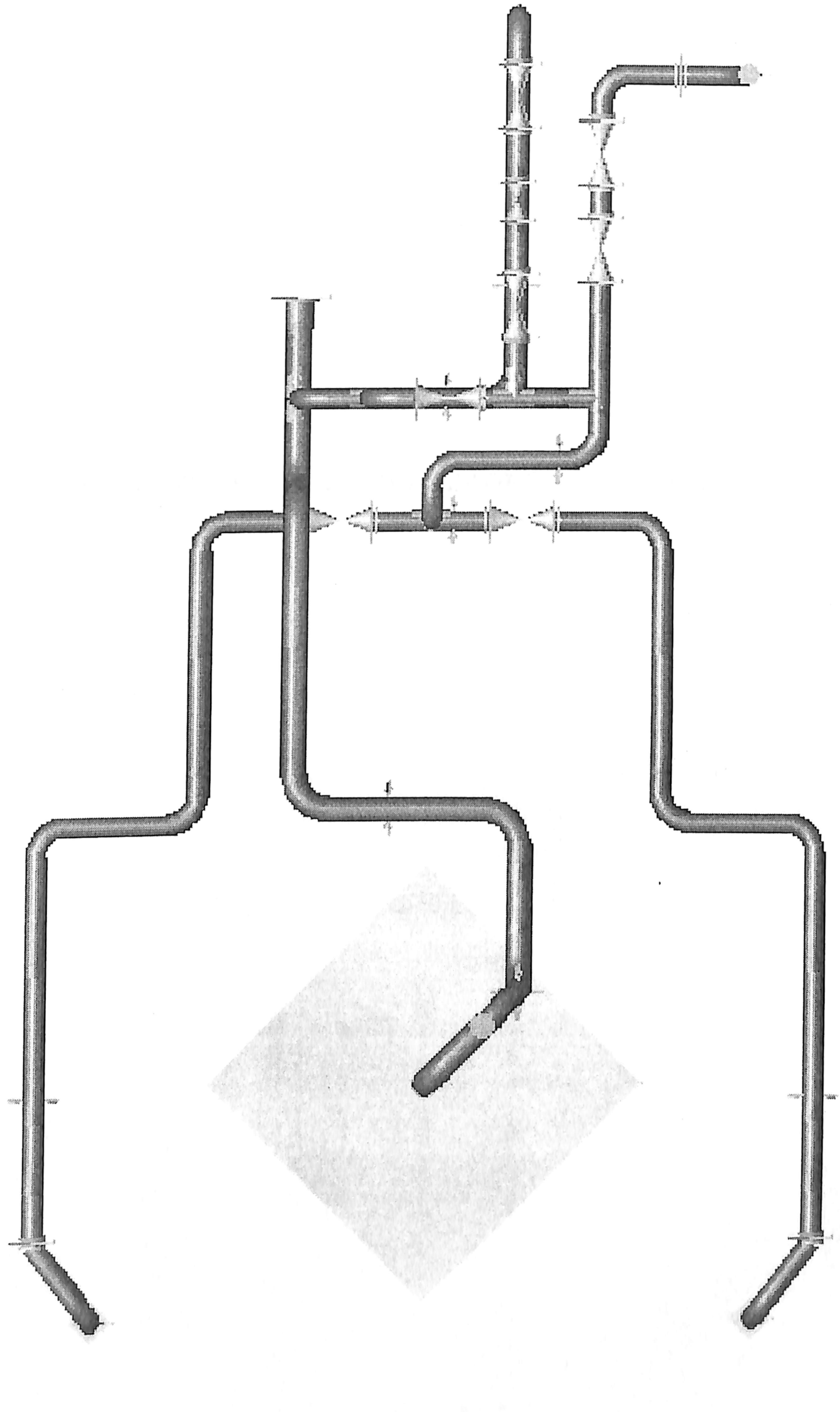


4.15 COMPRESSOR DISCHARGE LINE MODELING DIAGRAM IN CAESAR II ISOMETRIC VIEW



4.15 COMPRESSOR DISCHARGE LINE MODELING DIAGRAM IN CAESAR II

TOP VIEW



4.16 STRESS ANALYSIS REPORT - CAESAR II

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line

Table of Contents

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CAESAR  II   VERS 4.50                      APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line
----------------------------------------------------------------------------
```

INPUT LISTING

```
----------------------------------------------------------------------------
PIPE DATA
----------------------------------------------------------------------------
From  10  To  20 DY= 171.000 mm.
PIPE
Dia= 1,066.800 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.   Cor= 1.5000 mm.

GENERAL
T1= 27 C   T2= 120 C   P1=1200.0000 KPa   PHyd=1800.0000 KPa
Mat= (106)A106 B   E= 203,395,424 KPa   v = .292   Density= .0078 kg./cu.cm.
Insul= .0001 kg./cu.cm.   Fluid= .0009996 kg./cu.cm.

RIGID  Weight= 3,207.01 N.

RESTRAINTS
Node  10  ANC   Cnode  1000

UNIFORM LOAD
GX1= .26 g's   GY1= .00 g's   GZ1= .00 g's   GX2= .00 g's   GY2= .17 g's
GZ2= .00 g's   GX3= .00 g's   GY3= .00 g's   GZ3= .26 g's

WIND
Wind Shape= .650

ALLOWABLE STRESSES
B31.3 (2002)       Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa   Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa   Sh8= 137,892 KPa   Sh9= 137,892 KPa
----------------------------------------------------------------------------
From  20  To  30 DY= 1,603.000 mm.
BEND at "TO" end
Radius= 1,600.200 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 29
----------------------------------------------------------------------------
From  30  To  35  DX= -2,000.000 mm.
----------------------------------------------------------------------------
From  35  To  40  DX= -1,815.000 mm.
BEND at "TO" end
Radius= 1,600.200 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 39
Angle/Node @2= .00 38
----------------------------------------------------------------------------
From  40  To  45 DZ= 3,600.000 mm.
RESTRAINTS
Node  45  +Y   Mu = .30
----------------------------------------------------------------------------
From  45  To  60 DZ= 2,000.000 mm.
----------------------------------------------------------------------------
From  60  To  80 DZ= 6,000.000 mm.
----------------------------------------------------------------------------
From  80  To  85 DZ= 3,000.000 mm.
RESTRAINTS
Node  85  +Y   Mu = .30
Node  85  X
----------------------------------------------------------------------------
From  85  To  100 DZ= 3,775.000 mm.
BEND at "TO" end
Radius= 1,600.200 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 49
Angle/Node @2= .00 48
```

```
CAESAR  II   VERS 4.50                        APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line
-------------------------------------------------------------------------------
From  100  To  110  DX= 4,812.000 mm.

RESTRAINTS
Node  110  +Y   Mu = .30
-------------------------------------------------------------------------------
From  110  To  120  DX= 2,188.000 mm.
-------------------------------------------------------------------------------
From  120  To  130  DX= 171.000 mm.
RIGID  Weight= 3,933.10 N.
RESTRAINTS
Node  130  ANC   Cnode  131
-------------------------------------------------------------------------------
From  131  To  140  DX= 2,500.000 mm.
RIGID  Weight=60,000.00 N.
RESTRAINTS
Node  140  ANC   Cnode  141
-------------------------------------------------------------------------------
From  141  To  150  DX= 171.000 mm.
RIGID  Weight= 3,207.01 N.
-------------------------------------------------------------------------------
From  150  To  155  DX= 1,970.000 mm.
RESTRAINTS
Node  155  +Y   Mu = .30
Node  155  Z
-------------------------------------------------------------------------------
From  155  To  160  DX= 1,410.000 mm.
-------------------------------------------------------------------------------
From  160  To  170  DX= 171.000 mm.
RIGID  Weight= 3,207.01 N.
RESTRAINTS
Node  170  ANC   Cnode  171
-------------------------------------------------------------------------------
From  171  To  180  DX= 2,500.000 mm.
RIGID  Weight=60,000.00 N.
RESTRAINTS
Node  180  ANC   Cnode  181
-------------------------------------------------------------------------------
From  181  To  190  DX= 100.000 mm.
RIGID  Weight= 5,000.00 N.
RESTRAINTS
Node  190  ANC   Cnode  191
-------------------------------------------------------------------------------
From  191  To  200  DX= 171.000 mm.
RIGID  Weight= 3,207.01 N.
-------------------------------------------------------------------------------
From  200  To  210  DX= 500.000 mm.
-------------------------------------------------------------------------------
From  210  To  220  DX= 171.000 mm.
RIGID  Weight= 3,207.01 N.
RESTRAINTS
Node  220  ANC   Cnode  221
-------------------------------------------------------------------------------
From  221  To  230  DX= 2,500.000 mm.
RIGID  Weight=60,000.00 N.
RESTRAINTS
Node  230  ANC   Cnode  231
-------------------------------------------------------------------------------
From  231  To  240  DX= 171.000 mm.
RIGID  Weight= 3,207.01 N.
-------------------------------------------------------------------------------
```

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CAESAR  II   VERS 4.50                         APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line
From  240  To  250  DX= 1,600.000 mm.


BEND at "TO" end
Radius= 1,600.200 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 189
RESTRAINTS
Node  250  +Y   Mu = .30
-----------------------------------------------------------------------------
From  250  To  260 DZ= -4,100.000 mm.
BEND at "TO" end
Radius= 1,600.200 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 199
Angle/Node @2= .00 198
-----------------------------------------------------------------------------
From  260  To  270 DY= -5,482.000 mm.
BEND at "TO" end
Radius= 1,600.200 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 209
Angle/Node @2= .00 208
-----------------------------------------------------------------------------
From  270  To  273 DZ= -3,597.000 mm.
RESTRAINTS
Node  273  +Y   Mu = .30
Node  273  X
-----------------------------------------------------------------------------
From  273  To  276 DZ= -6,567.000 mm.
-----------------------------------------------------------------------------
From  276  To  278 DZ= -2,500.000 mm.
RESTRAINTS
Node  278  +Y   Mu = .30
-----------------------------------------------------------------------------
From  278  To  280 DZ= -2,500.000 mm.
-----------------------------------------------------------------------------
From  280  To  290 DZ= -171.000 mm.
RIGID  Weight= 3,207.01 N.
RESTRAINTS
Node  290  ANC   Cnode  300
DISPLACEMENTS
Node  300   DX1= .000 mm.   DY1= .000 mm.   DZ1= 1.000 mm.   RX1= .000
RY1= .000   RZ1= .000   DX2= .000 mm.   DY2= .000 mm.   DZ2= 2.000 mm.
RX2= .000   RY2= .000   RZ2= .000
-----------------------------------------------------------------------------
From  1000  To  1010 DY= -1,850.000 mm.
-----------------------------------------------------------------------------
PIPE DATA
Dia= 7,496.000 mm.   Wall= 48.000 mm.   Insul= .000 mm.   Cor= 3.0000 mm.
GENERAL
T1= 27 C   T2= 120 C   P1=1200.0000 KPa   PHyd=1800.0000 KPa
Mat= (106)A106 B   E= 203,395,424 KPa   v = .292   Density= .0078 kg./cu.cm.
Insul= .0001 kg./cu.cm.   Fluid= .0009996 kg./cu.cm.

ALLOWABLE STRESSES
B31.3 (2002)       Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa   Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa   Sh8= 137,892 KPa   Sh9= 137,892 KPa
-----------------------------------------------------------------------------
From  1010  To  1020 DY= -4,500.000 mm.
-----------------------------------------------------------------------------
From  1020  To  1030 DY= -1,850.000 mm.
-----------------------------------------------------------------------------
From  1030  To  1040 DY= -5,650.000 mm.
RESTRAINTS
Node  1040  ANC
```

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line

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CEASER II LOAD CASE REPORT

CASE 1 (HYD) WW+HP
HYDRO TEST CASE

CASE 2 (OPE) W+D1+T1+P1
OPERATING CASE CONDITION 1

CASE 3 (OPE) W+D2+T2+P1
OPERATING CASE CONDITION 2

CASE 4 (SUS) W+P1
SUSTAINED CASE CONDITION 1

CASE 5 (OPE) W+D1+T1+P1+U1

CASE 6 (OPE) W+D1+T1+P1-U1

CASE 7 (OPE) W+D1+T1+P1+U2

CASE 8 (OPE) W+D1+T1+P1-U2

CASE 9 (OPE) W+D1+T1+P1+U3

CASE 10 (OPE) W+D1+T1+P1-U3

CASE 11 (OPE) W+D1+T1+P1+WIN1

CASE 12 (OPE) W+D1+T1+P1-WIN1

CASE 13 (OPE) W+D1+T1+P1+WIN2

CASE 14 (OPE) W+D1+T1+P1-WIN2

CASE 15 (EXP) L15=L2-L4

CASE 16 (EXP) L16=L3-L4

CASE 17 (OCC) L17=L5-L2

CASE 18 (OCC) L18=L6-L2

CASE 19 (OCC) L19=L7-L2

CASE 20 (OCC) L20=L8-L2

CASE 21 (OCC) L21=L9-L2

CASE 22 (OCC) L22=L10-L2

CASE 23 (OCC) L23=L11-L2

CASE 24 (OCC) L24=L12-L2

CASE 25 (OCC) L25=L13-L2

CASE 26 (OCC) L26=L14-L2

CASE 27 (OCC) L27=L4+L17

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line

CASE 28 (OCC) L28=L4+L18

CASE 29 (OCC) L29=L4+L19

CASE 30 (OCC) L30=L4+L20

CASE 31 (OCC) L31=L4+L21

CASE 32 (OCC) L32=L4+L22

CASE 33 (OCC) L33=L4+L23

CASE 34 (OCC) L34=L4+L24

CASE 35 (OCC) L35=L4+L25

CASE 36 (OCC) L36=L4+L26

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line

DISPLACEMENT REPORT, Nodal Movements
CASE 2 (OPE) W+D1+T1+P1

	-----Translations(mm.)------			-------Rotations(deg.)-------		
NODE	DX	DY	DZ	RX	RY	RZ
10	0.002	0.911	-0.002	0.0000	0.0000	0.0000
20	0.002	0.923	-0.002	0.0000	0.0000	0.0000
29	-0.203	0.957	-0.188	-0.0137	-0.0070	0.0172
30	-0.509	0.543	-0.549	-0.0165	-0.0137	0.0259
35	-0.555	0.360	-0.649	-0.0164	-0.0137	0.0259
38	-0.579	0.262	-0.702	-0.0163	-0.0137	0.0258
39	-0.747	-0.065	-0.803	-0.0163	0.0009	0.0222
40	-0.621	-0.028	-0.622	-0.0019	0.0136	0.0259
45	-0.136	0.000	-0.395	0.0038	0.0125	0.0260
48	-0.736	-0.152	1.056	0.0064	-0.0198	0.0270
49	-1.037	-0.484	1.311	0.0398	-0.0090	0.0166
60	0.250	-0.294	-0.176	0.0079	0.0092	0.0262
80	0.531	-0.414	0.481	-0.0071	-0.0054	0.0266
85	0.000	0.000	0.810	-0.0018	-0.0155	0.0269
100	-0.920	-0.594	1.296	0.0464	0.0128	0.0110
110	-0.561	0.000	0.567	0.0532	0.0101	0.0058
120	-0.321	0.053	0.281	0.0578	0.0048	0.0008
130	-0.309	0.055	0.266	0.0578	0.0047	0.0008
131	-0.309	0.055	0.266	0.0578	0.0047	0.0008
140	-0.135	0.091	0.069	0.0582	0.0043	0.0006
141	-0.135	0.091	0.069	0.0582	0.0043	0.0006
150	-0.123	0.094	0.056	0.0583	0.0042	0.0006
155	0.093	0.000	0.000	0.0624	-0.0011	-0.0141
160	0.250	-0.605	0.080	0.0654	-0.0045	-0.0239
170	0.262	-0.678	0.093	0.0654	-0.0045	-0.0239
171	0.262	-0.678	0.093	0.0654	-0.0045	-0.0239
180	0.437	-1.724	0.296	0.0658	-0.0047	-0.0232
181	0.437	-1.724	0.296	0.0658	-0.0047	-0.0232
189	0.722	-1.785	0.388	0.0861	0.0225	0.0447
190	0.444	-1.764	0.305	0.0658	-0.0047	-0.0232
191	0.444	-1.764	0.305	0.0658	-0.0047	-0.0232
198	-0.265	0.483	-0.075	0.0304	0.0282	0.0309
199	-0.481	0.435	-0.126	-0.0232	0.0215	0.0299
200	0.455	-1.834	0.319	0.0658	-0.0047	-0.0231
208	0.403	-0.225	2.222	-0.0409	0.0213	0.0140
209	0.407	-0.497	2.658	-0.0055	0.0208	0.0072
210	0.511	-2.024	0.364	0.0669	-0.0049	-0.0189
220	0.523	-2.080	0.379	0.0669	-0.0049	-0.0188
221	0.523	-2.080	0.379	0.0669	-0.0049	-0.0188
230	0.698	-2.862	0.595	0.0673	-0.0048	-0.0173
231	0.698	-2.862	0.595	0.0673	-0.0048	-0.0173
240	0.710	-2.913	0.609	0.0673	-0.0048	-0.0172
250	0.184	0.000	0.028	0.0343	0.0288	0.0323
260	-0.191	0.037	0.532	-0.0422	0.0240	0.0161
270	0.182	-0.390	2.493	0.0112	0.0063	0.0103
273	0.000	0.000	2.266	0.0049	0.0039	0.0088
276	-0.084	-0.168	1.550	0.0022	-0.0010	0.0038
278	-0.030	0.000	1.278	0.0020	-0.0010	0.0019
280	0.000	0.000	1.012	0.0000	0.0000	0.0000
290	0.000	0.000	1.000	0.0000	0.0000	0.0000
300	0.000	0.000	1.000	0.0000	0.0000	0.0000
1000	0.002	0.911	-0.002	0.0000	0.0000	0.0000
1010	0.001	0.789	-0.001	0.0000	0.0000	0.0000
1020	0.001	0.493	-0.001	0.0000	0.0000	0.0000
1030	0.001	0.372	-0.001	0.0000	0.0000	0.0000
1040	0.000	0.000	0.000	0.0000	0.0000	0.0000

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line

DISPLACEMENT REPORT, Nodal Movements
CASE 4 (SUS) W+P1

	-----Translations(mm.)------			---------Rotations(deg.)-------		
NODE	DX	DY	DZ	RX	RY	RZ
10	0.001	0.000	-0.001	0.0000	0.0000	0.0000
20	0.001	0.000	-0.001	0.0000	0.0000	0.0000
29	-0.126	-0.008	-0.148	-0.0115	-0.0047	0.0103
30	-0.276	-0.213	-0.400	-0.0140	-0.0082	0.0099
35	-0.296	-0.283	-0.459	-0.0141	-0.0081	0.0098
38	-0.306	-0.319	-0.490	-0.0142	-0.0081	0.0097
39	-0.389	-0.310	-0.563	-0.0160	-0.0005	0.0040
40	-0.343	-0.098	-0.489	-0.0038	0.0057	0.0074
45	-0.139	0.000	-0.391	0.0024	0.0052	0.0086
48	-0.232	-0.117	0.209	0.0052	-0.0062	0.0164
49	-0.313	-0.444	0.300	0.0327	-0.0021	0.0091
60	0.020	-0.265	-0.301	0.0075	0.0038	0.0098
80	0.162	-0.412	-0.032	-0.0067	-0.0015	0.0133
85	0.000	0.000	0.103	-0.0023	-0.0048	0.0151
100	-0.255	-0.562	0.288	0.0364	0.0043	0.0101
110	-0.099	0.000	0.057	0.0427	0.0027	0.0053
120	0.002	0.038	0.000	0.0470	0.0004	0.0007
130	0.003	0.040	-0.001	0.0471	0.0004	0.0007
131	0.003	0.040	-0.001	0.0471	0.0004	0.0007
140	0.013	0.073	-0.015	0.0474	0.0003	0.0006
141	0.013	0.073	-0.015	0.0474	0.0003	0.0006
150	0.014	0.075	-0.016	0.0474	0.0003	0.0006
155	0.106	0.000	0.000	0.0513	-0.0010	-0.0128
160	0.174	-0.559	0.036	0.0541	-0.0017	-0.0216
170	0.175	-0.624	0.041	0.0541	-0.0017	-0.0216
171	0.175	-0.624	0.041	0.0541	-0.0017	-0.0216
180	0.186	-1.566	0.114	0.0545	-0.0017	-0.0208
181	0.186	-1.566	0.114	0.0545	-0.0017	-0.0208
189	0.236	-1.509	0.134	0.0737	0.0083	0.0463
190	0.186	-1.602	0.117	0.0545	-0.0017	-0.0208
191	0.186	-1.602	0.117	0.0545	-0.0017	-0.0208
198	-0.156	0.209	-0.054	0.0137	0.0119	0.0308
199	-0.153	0.030	-0.001	-0.0182	0.0136	0.0266
200	0.187	-1.664	0.122	0.0545	-0.0017	-0.0207
208	0.430	-0.295	0.724	-0.0098	0.0167	0.0079
209	0.371	-0.345	0.746	0.0054	0.0166	0.0027
210	0.211	-1.832	0.138	0.0555	-0.0017	-0.0163
220	0.212	-1.881	0.143	0.0555	-0.0017	-0.0162
221	0.212	-1.881	0.143	0.0555	-0.0017	-0.0162
230	0.223	-2.548	0.215	0.0559	-0.0016	-0.0147
231	0.223	-2.548	0.215	0.0559	-0.0016	-0.0147
240	0.224	-2.591	0.220	0.0559	-0.0016	-0.0146
250	0.034	0.000	-0.009	0.0175	0.0120	0.0323
260	0.086	-0.178	0.301	-0.0113	0.0183	0.0098
270	0.162	-0.195	0.622	0.0060	0.0055	0.0053
273	0.000	0.000	0.523	0.0009	0.0034	0.0045
276	-0.063	-0.218	0.223	0.0034	-0.0009	0.0020
278	-0.017	0.000	0.109	0.0026	-0.0007	0.0010
280	0.000	0.000	0.001	0.0000	0.0000	0.0000
290	0.000	0.000	0.000	0.0000	0.0000	0.0000
300	0.000	0.000	0.000	0.0000	0.0000	0.0000
1000	0.001	0.000	-0.001	0.0000	0.0000	0.0000
1010	0.001	0.000	-0.001	0.0000	0.0000	0.0000
1020	0.000	0.000	0.000	0.0000	0.0000	0.0000
1030	0.000	0.000	0.000	0.0000	0.0000	0.0000
1040	0.000	0.000	0.000	0.0000	0.0000	0.0000

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CAESAR  II   VERS 4.50                   APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY
                  ---Forces(N. )---  ---Moments(N.m.)----    --Displacements(mm.)--
NODE CASE TYPE  FX      FY       FZ      MX       MY       MZ     DX        DY       DZ
10                    Rigid ANC
      1   HYD  1097. -42434. -10642.-18652. -17967. 5991. 0.0011 -0.0002 -0.0013
      2   OPE  16820.-47736. -14767.-18594. -24932. 9183. 0.0017  0.9107 -0.0017
      4   SUS  7637. -41155. -5988. -14970. -8343.  8623. 0.0007 -0.0002 -0.0007
MAX.  2        16820. 47736. 14767. 18652/1  24932. 9183. 0.002   0.911   0.002

45                    Rigid +Y
      1   HYD -9476. -116512. -33645   0.       0.      0.   -0.1654 0.0000 -0.5874
      2   OPE -10722.-109515. -31056.  0.       0.      0.   -0.1362 0.0000 -0.3947
      4   SUS -11876.-117920. -33323.  0.       0.      0.   -0.1395 0.0000 -0.3914
MAX.  1       11876/4 117920/4 33645/1 0./1    0./1   0./1   0.165/1 0.000/4 0.5874

85                    Rigid +Y Rigid X
      1   HYD -18522. -108423. 31008.  0.       0.      0.    0.0000 0.0000  0.1771
      2   OPE -36645. -111574. 33472.  0.       0.      0.    0.0000 0.0000  0.8100
      4   SUS -11903. -108173. 18049.  0.       0.      0.    0.0000 0.0000  0.1031
MAX.            36645.  111574. 33472.  0./1    0./1   0./1   0.0000 0.0000  0.8100

110                   Rigid +Y
      1   HYD -25212. -99393.  15920.  0.       0.      0.   -0.1683 0.0000 0.1063
      2   OPE -20291. -96207.  20526.  0.       0.      0.   -0.5609 0.0000 0.5674
      4   SUS -17387. -99994.  9915.   0.       0.      0.   -0.0993 0.0000 0.0566
MAX.          25212/1  99994/4 20526/2 0/1      0/1    0/1   0.561/2 0.00/4 0.57/2

130                   Rigid ANC
      1   HYD  39746.  19045.  -2318. -32433.  29141. 5213.-0.0142 0.0444 0.0127
      2   OPE  50844.  17314.   1121. -33865.  52062. 9190.-0.3093 0.0549 0.2663
      4   SUS  28217.  19526.  -1701. -31495.  19427. 3272. 0.0030 0.0397-0.0008
MAX.          50844/2 19526/4  2318/1 33865/2 52062/2 9190/20.309/20.055/20.27/2

140                   Rigid ANC
      1   HYD  39746. -62580.  -2318. -32433. 23346. 59632. 0.0015 0.0783 -0.017
      2   OPE  50844. -64311.   1121. -33865. 54865. 67936.-0.1350 0.0914  0.069
      4   SUS  28217. -62098.  -1701. -31495. 15175. 56487. 0.0134 0.0730 -0.015
MAX.  2        50844   64311   2318/1  33865  54865  67936  0.135  0.091   0.069

155                   Rigid +Y Rigid Z
      1   HYD  24577. -228069.  1806.   0.       0.     0.    0.1403  0.      0.
      2   OPE  16233. -231284.  11849.  0.       0.     0.    0.0927  0.      0.
      4   SUS  18489. -227090.  1020.   0.       0.     0.    0.1056  0.      0.
MAX.          24577/1  231284/2 11849/2 0./1     0./1   0./1 0.140/1 0./2    0./2

170                   Rigid ANC
      1   HYD  15170. 116397. -4124. -32433. 11864. 23338. 0.2441 -0.6384  0.059
      2   OPE  34610. 117881. -10727.-33865. 40306. 33000. 0.2618 -0.6778  0.093
      4   SUS  9728.  115900. -2721. -31495. 7232.  19947  0.1748 -0.6241  0.041
MAX.           34610. 117881.  10727. 33865. 40306. 33000. 0.2628  0.6778  0.093

180                   Rigid ANC
      1   HYD  15170. 34772.  -4124. -32433. 1554. -165625.0.2605 -1.6076  0.169
      2   OPE  34610. 36256.  -10727.-33865. 13487.-159672.0.4365 -1.7235  0.296
      4   SUS  9728.  34275.  -2721. -31495. 429.  -167774.0.1858 -1.5659  0.114
MAX.  2        34610. 36256.   10727. 33865. 13487. 167774/4 0.437 1.724   0.296

190                   Rigid ANC
      1   HYD 15170. 28907. -4124.  -32433  1142. -168809. 0.2612 -1.6452  0.173
```

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Suction Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY

			---Forces(N.)---			---Moments(N.m.)----			--Displacements(mm.)--		
NODE	CASE	TYPE	FX	FY	FZ	MX	MY	MZ	DX	DY	DZ
	2	OPE	34610.	30391.	-10727.	-33865	12414.	-163005.	0.4435	-1.7642	0.305
	4	SUS	9728.	28410.	-2721.	-31495	157.	-170908.	0.1862	-1.6023	0.117
MAX.			34610	30391	10727	33865	12414	170908/4	0.444	1.7642	0.305
220				Rigid ANC							
	1	HYD	15170.	13659.	-4124.	-32433.	-2330.	-186730.	0.2998	-1.9334	0.212
	2	OPE	34610.	15143.	-10727.	-33865.	3382.	-182175.	0.5231	-2.0801	0.379
	4	SUS	9728.	13162.	-2721.	-31495.	-2134.	-188410.	0.2120	-1.8806	0.143
MAX.	2		34610.	15143.	10727.	33865.	3382.	188410/4	0.523	2.0801	0.379
230				Rigid ANC							
	1	HYD	15170.	-67965.	-4124.	-32433.	-12639.	-118847.	0.3162	-2.6311	0.321
	2	OPE	34610.	-66481.	-10727.	-33865.	-23437.	-118002.	0.6979	-2.8620	0.595
	4	SUS	9728.	-68462.	-2721.	-31495.	-8937.	-119284.	0.2229	-2.5480	0.215
MAX.	2		34610	68462	10727	33865.	23437	119284/4	0.698	2.862	0.595
250				Rigid +Y							
	1	HYD	11709.	-163622.	351.	0.	0.	0.	0.0669	0.0000	0.002
	2	OPE	32307.	-147704.	4823.	0.	0.	0.	0.1845	0.0000	0.028
	4	SUS	5942.	-168770.	-1587.	0.	0.	0.	0.0339	0.0000	-0.009
MAX.	2		32307	168770/4	4823	0./1	0./1	0./1	0.1845	0./4	0.028
273				Rigid +Y Rigid X							
	1	HYD	6911.	-117830.	35349.	0.	0.	0.	0.0000	0.0000	0.803
	2	OPE	5771.	-135735.	40720.	0.	0.	0.	0.0000	0.0000	2.266
	4	SUS	7165.	-111949.	33585.	0.	0.	0.	0.0000	0.0000	0.523
MAX.			7165/4	135735/2	40720/2	0./1	0./1	0./ 1	0.000/4	0.00/2	0.27/2
278				Rigid +Y							
	1	HYD	-2609.	-82360.	24570.	0.	0.	0.	-0.0179	0.0000	0.169
	2	OPE	-534.	-75337.	22595.	0.	0.	0.	-0.0302	0.0000	1.278
	4	SUS	-3036.	-84848.	19130.	0.	0.	0.	-0.0173	0.0000	0.109
MAX.			3036/4	84848/4	24570/1	0./1	0./1	0./1	0.030/2	0./4	1.28/2
290				Rigid ANC							
	1	HYD	-397.	1080.	-64169.	243.	-6906.	7635.	0.0000	0.0000	0.000
	2	OPE	-3076.	-2472.	-78133.	1746.	-12665.	12197.	0.0000	0.0000	1.000
	4	SUS	-344.	2339.	-53703.	-289.	-6669.	6298.	0.0000	0.0000	0.000
MAX.	2		3076.	2472	78133.	1746.	12665.	12197.	0.0000	0.0000	1.000
300				Displ. Reaction							
	1	HYD	-397.	1080.	-64169.	243.	-6906.	7635.	0.0000	0.0000	0.000
	2	OPE	-3076.	-2472.	-78133.	1746.	-12665.	12197.	0.0000	0.0000	1.000
	4	SUS	-344.	2339.	-53703.	-289.	-6669.	6298.	0.0000	0.0000	0.000
MAX.	2		3076.	2472.	78133.	1746.	12665.	12197.	0.0/1	0.0/1	1.0/2
1040				Rigid ANC							
	1	HYD	11097.	-42434.	-10642.	-166040.	-17967.	-147707.	0.	0.	0.
	2	OPE	16820.	-47736.	-14767.	-223119.	-24932.	-223775.	0.	0.	0.
	4	SUS	7637.	-41155.	-5988.	-97902.	-8343.	-97145.	0.	0.	0.
MAX.	2		16820.	47736.	14767.	223119.	24932.	223775.	0.	0.	0.

```
CAESAR  II   VERS 4.50                      APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line
```

STRESS SUMMARY

PIPING CODE: B31.3 -2002, April 30, 2002

CASE 1 (HYD WW+HP)

```
****          CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:36.7  @NODE   250   STRESS:67228.4   ALLOWABLE:   183396.
BENDING STRESS:          30871.2  @NODE   250
TORSIONAL STRESS:         1480.6  @NODE   100
AXIAL STRESS:            36986.9  @NODE   199
HOOP  STRESS:            73799.8  @NODE    29
3D MAX INTENSITY:        76729.1  @NODE   240
```

CASE 4 (SUS) W+P1

```
****          CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:45.7  @NODE   250    STRESS:62962.3   ALLOWABLE:   137892.
BENDING STRESS:          35357.4  @NODE   250
TORSIONAL STRESS:         1623.5  @NODE   100
AXIAL STRESS:            28432.3  @NODE   199
HOOP  STRESS:            55949.9  @NODE    29
3D MAX INTENSITY:        63732.0  @NODE   250
```

CASE 15 (EXP) L15=L2-L4

```
****          CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:4.3   @NODE   199   STRESS:8805.5   ALLOWABLE:   206838.
BENDING STRESS:           8795.2  @NODE   199
TORSIONAL STRESS:          757.3  @NODE    20
AXIAL STRESS:              591.7  @NODE   160
HOOP  STRESS:                0.0  @NODE    20
3D MAX INTENSITY:        10577.4  @NODE   199
```

CASE 16 (EXP) L16=L3-L4

```
****          CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:37.0  @NODE   155   STRESS:76462.8   ALLOWABLE:   206838.
BENDING STRESS:          76353.0  @NODE   155
TORSIONAL STRESS:        14648.4  @NODE    20
AXIAL STRESS:             4379.6  @NODE   199
HOOP  STRESS:                0.0  @NODE    20
3D MAX INTENSITY:        88732.6  @NODE   155
```

```
CAESAR  II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line
```

CASE 27 (OCC) L27=L4+L17

```
****            CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)

CODE STRESS %:34.9  @NODE   250   STRESS:63950.4   ALLOWABLE:   183396.

BENDING STRESS:          36288.4  @NODE   250

TORSIONAL STRESS:         1643.2  @NODE   100

AXIAL STRESS:            29153.6  @NODE   155

HOOP  STRESS:            55949.9  @NODE    29

3D MAX INTENSITY:        67208.1  @NODE    85
```

CASE 28 (OCC) L28=L4+L18

```
****            CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)

CODE STRESS %:37.0  @NODE   250   STRESS:67846.3   ALLOWABLE:   183396.

BENDING STRESS:          40215.1  @NODE   250

TORSIONAL STRESS:         1675.2  @NODE   100

AXIAL STRESS:            28736.0  @NODE   155

HOOP  STRESS:            55949.9  @NODE    29

3D MAX INTENSITY:        68633.2  @NODE   250
```

CASE 29 (OCC) L29=L4+L19

```
****            CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)

CODE STRESS %:37.7  @NODE   250   STRESS:69221.8   ALLOWABLE:   183396.

BENDING STRESS:          41593.0  @NODE   250

TORSIONAL STRESS:         1914.0  @NODE    49

AXIAL STRESS:            28607.6  @NODE   199

HOOP  STRESS:            55949.9  @NODE    29

3D MAX INTENSITY:        70007.3  @NODE   250
```

CASE 30 (OCC) L30=L4+L20

```
****            CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)

CODE STRESS %:37.8  @NODE   250   STRESS:69285.1   ALLOWABLE:   183396.

BENDING STRESS:          41672.0  @NODE   250

TORSIONAL STRESS:         1884.0  @NODE   100

AXIAL STRESS:            28616.3  @NODE   199

HOOP  STRESS:            55949.9  @NODE    29

3D MAX INTENSITY:        70073.7  @NODE   250
```

```
CAESAR  II   VERS 4.50                      APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line
```

CASE 31 (OCC) L31=L4+L21

```
****           CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:35.7  @NODE   250   STRESS:65436.6   ALLOWABLE:   183396.
BENDING STRESS:           37177.2  @NODE   250
TORSIONAL STRESS:          1665.0  @NODE   100
AXIAL STRESS:             28498.8  @NODE   260
HOOP  STRESS:             55949.9  @NODE    29
3D MAX INTENSITY:         68299.6  @NODE   155
```

CASE 32 (OCC) L32=L4+L22

```
****           CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:38.1  @NODE   240   STRESS:69868.1   ALLOWABLE:   183396.
BENDING STRESS:           42350.5  @NODE   240
TORSIONAL STRESS:          1919.6  @NODE    20
AXIAL STRESS:             28469.3  @NODE   199
HOOP  STRESS:             55949.9  @NODE    29
3D MAX INTENSITY:         71498.3  @NODE   240
```

CASE 33 (OCC) L33=L4+L23

```
****           CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:34.8  @NODE   250   STRESS:63807.8   ALLOWABLE:   183396.
BENDING STRESS:           36185.2  @NODE   250
TORSIONAL STRESS:          1646.8  @NODE   100
AXIAL STRESS:             28435.1  @NODE   199
HOOP  STRESS:             55949.9  @NODE    29
3D MAX INTENSITY:         64581.7  @NODE   250
```

CASE 34 (OCC) L34=L4+L24

```
****           CODE STRESS CHECK PASSED
PIPING CODE: B31.3 -2002, April 30, 2002

HIGHEST STRESSES: (KPa)
CODE STRESS %:34.7  @NODE   250   STRESS:63632.4   ALLOWABLE:   183396.
BENDING STRESS:           36026.0  @NODE   250
TORSIONAL STRESS:          1629.6  @NODE   100
AXIAL STRESS:             28432.7  @NODE   199
HOOP  STRESS:             55949.9  @NODE    29
3D MAX INTENSITY:         64405.5  @NODE   250
```

```
CAESAR  II   VERS 4.50                        APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line
```

CASE 35 (OCC) L35=L4+L25

```
****             CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)

CODE STRESS %:34.5  @NODE    250    STRESS:63266.6   ALLOWABLE:    183396.
BENDING STRESS:           35588.8   @NODE    250
TORSIONAL STRESS:          1641.9   @NODE    100
AXIAL STRESS:             28454.0   @NODE    199
HOOP  STRESS:             55949.9   @NODE     29
3D MAX INTENSITY:         64036.6   @NODE    250
```

CASE 36 (OCC) L36=L4+L26

```
****             CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)

CODE STRESS %:34.4  @NODE    250    STRESS:63047.7   ALLOWABLE:    183396.
BENDING STRESS:           35395.4   @NODE    250
TORSIONAL STRESS:          1625.7   @NODE    100
AXIAL STRESS:             28458.1   @NODE    199
HOOP  STRESS:             55949.9   @NODE     29
3D MAX INTENSITY:         63817.3   @NODE    250
```

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

Table of Contents

```
CAESAR  II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line
```

INPUT LISTING

```
-----------------------------------------------------------------------
PIPE DATA
-----------------------------------------------------------------------
From  10  To  20 DY= 213.000 mm.
PIPE
Dia= 762.000 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.   Cor= 1.5000 mm.
GENERAL
T1= 55 C   T2= 120 C   P1=2000.0000 KPa   PHyd=3000.0000 KPa
Mat= (106)A106 B   E= 203,395,424 KPa   v = .292   Density= .0078 kg./cu.cm.
Insul= .0001 kg./cu.cm.   Fluid= .0004750 kg./cu.cm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  10  ANC   Cnode  2000
DISPLACEMENTS
Node  2000   DX1= .000 mm.   DY1= .000 mm.   DZ1= .000 mm.   RX1= .000
RY1= .000   RZ1= .000   DX2= 2.312 mm.   DY2= 2.312 mm.   DZ2= 2.312 mm.
RX2= .000   RY2= .000   RZ2= .000
UNIFORM LOAD
GX1= .26 g's   GY1= .00 g's   GZ1= .00 g's   GX2= .00 g's   GY2= .17 g's
GZ2= .00 g's   GX3= .00 g's   GY3= .00 g's   GZ3= .26 g's
WIND
Wind Shape= .650
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa   Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa   Sh8= 137,892 KPa   Sh9= 137,892 KPa
-----------------------------------------------------------------------
From  20  To  30 DY= 3,800.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 29
Angle/Node @2= .00 28
HANGERS
Hanger Node = 30   Hanger Table = 0.0   Available Space = .0000 mm.
Allowed Load Variation = 25.0000   Max Allowed Travel = 40.0000 mm.
No. Hangers = 0.0   Short Range Flag = -1   User Operating Load = .00 N.
Free Node = 10   Free Node = 0   Free Code = 0.0   Spring Rate = .00 N./mm.
Theoretical Cold Load = .00 N.
-----------------------------------------------------------------------
From  30  To  35  DX= -1,200.000 mm.
-----------------------------------------------------------------------
From  35  To  40  DX= -1,176.000 mm.
-----------------------------------------------------------------------
From  40  To  50  DX= -213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  50  ANC   Cnode  51
-----------------------------------------------------------------------
From  51  To  60  DX= -213.000 mm.
RIGID  Weight= 4,141.09 N.
-----------------------------------------------------------------------
From  60  To  65  DX= -1,636.000 mm.
RESTRAINTS
Node  65  +Y
-----------------------------------------------------------------------
From  65  To  70  DX= -1,143.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 69
-----------------------------------------------------------------------
From  70  To  80 DZ= 1,532.000 mm.
-----------------------------------------------------------------------
```

```
CAESAR  II   VERS 4.50                      APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

------------------------------------------------------------------------------
From  80  To  90 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  90  ANC   Cnode  91
------------------------------------------------------------------------------
From  91  To  100 DZ= 91.000 mm.
RIGID  Weight= 7,600.00 N.
RESTRAINTS
Node  100  ANC   Cnode  101
------------------------------------------------------------------------------
From  101  To  110 DZ= 2,400.000 mm.
RIGID  Weight=50,982.98 N.
RESTRAINTS
Node  110  ANC   Cnode  111
------------------------------------------------------------------------------
From  111  To  120 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
------------------------------------------------------------------------------
From  120  To  130 DZ= 818.000 mm.
------------------------------------------------------------------------------
From  130  To  140 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  140  ANC   Cnode  141
------------------------------------------------------------------------------
From  141  To  150 DZ= 2,400.000 mm.
RIGID  Weight=50,983.00 N.
RESTRAINTS
Node  150  ANC   Cnode  151
------------------------------------------------------------------------------
From  151  To  160 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
------------------------------------------------------------------------------
From  160  To  165 DZ= 2,059.000 mm.
RESTRAINTS
Node  165  +Y   Mu = .30
------------------------------------------------------------------------------
From  165  To  170 DZ= 2,110.000 mm.
SIF's & TEE's
Node  170   Welding Tee
------------------------------------------------------------------------------
From  170  To  180 DZ= 2,339.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 179
Angle/Node @2= .00 178
------------------------------------------------------------------------------
From  180  To  182  DX= -1,500.000 mm.
RESTRAINTS
Node  182  Z
------------------------------------------------------------------------------
From  182  To  185  DX= -2,286.000 mm.
------------------------------------------------------------------------------
From  185  To  187  DX= -1,300.000 mm.
------------------------------------------------------------------------------
From  187  To  190  DX= -1,192.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 189
Angle/Node @2= .00 188
------------------------------------------------------------------------------
From  190  To  195 DZ= 2,286.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 194
```

```
CAESAR II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

-----------------------------------------------------------------------------
From  195  To  198 DY= -1,969.000 mm.
-----------------------------------------------------------------------------
From  198  To  200 DY= -2,491.000 mm.
-----------------------------------------------------------------------------
From  200  To  210 DY= -559.000 mm.
SIF's & TEE's
Node  210   Welding Tee
-----------------------------------------------------------------------------
From  210  To  215  DX= 800.000 mm.
RESTRAINTS
Node  215  +Y   Mu = .30
Node  215  Z
-----------------------------------------------------------------------------
From  215  To  220  DX= 1,259.000 mm.
-----------------------------------------------------------------------------
From  220  To  230  DX= 213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  230  ANC   Cnode  231
-----------------------------------------------------------------------------
From  231  To  240  DX= 2,400.000 mm.
RIGID  Weight=50,982.98 N.
RESTRAINTS
Node  240  ANC   Cnode  241
-----------------------------------------------------------------------------
From  241  To  250  DX= 213.000 mm.
RIGID  Weight= 4,141.09 N.
-----------------------------------------------------------------------------
From  250  To  255  DX= 1,100.000 mm.
RESTRAINTS
Node  255  +Y   Mu = .30
-----------------------------------------------------------------------------
From  255  To  260  DX= 2,765.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000
-----------------------------------------------------------------------------
From  260  To  265 DZ= 9,000.000 mm.
RESTRAINTS
Node  265  +Y   Mu = .30
Node  265  Z
-----------------------------------------------------------------------------
From  265  To  270 DZ= 2,287.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 269
Angle/Node @2= .00 268
-----------------------------------------------------------------------------
From  270  To  275  DX= 4,000.000 mm.
RESTRAINTS
Node  275  +Y   Mu = .30
-----------------------------------------------------------------------------
From  275  To  280  DX= 1,951.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 279
Angle/Node @2= .00 278
-----------------------------------------------------------------------------
From  280  To  285 DZ= 10,200.000 mm.
RESTRAINTS
Node  285  +Y
Node  285  X
-----------------------------------------------------------------------------
From  285  To  288 DZ= 2,000.000 mm.
-----------------------------------------------------------------------------
```

```
CAESAR II   VERS 4.50                          APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

From  288  To  290 DZ= 3,071.000 mm.
--------------------------------------------------------------------------------
From  290  To  300 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  300  ANC   Cnode  301
--------------------------------------------------------------------------------
From  301  To  310 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
--------------------------------------------------------------------------------
From  310  To  315  DX= -2,201.000 mm.  DZ= 2,883.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 314
--------------------------------------------------------------------------------
From  315  To  330 DY= -1,492.000 mm.
--------------------------------------------------------------------------------
From  330  To  340 DY= -213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  340  ANC   Cnode  341
--------------------------------------------------------------------------------
From  210  To  720  DX= -2,059.000 mm.
--------------------------------------------------------------------------------
From  720  To  730  DX= -213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  730  ANC   Cnode  731
--------------------------------------------------------------------------------
From  731  To  740  DX= -2,400.000 mm.
RIGID  Weight=50,982.98 N.
RESTRAINTS
Node  740  ANC   Cnode  741
--------------------------------------------------------------------------------
From  741  To  750  DX= -213.000 mm.
RIGID  Weight= 4,141.09 N.
--------------------------------------------------------------------------------
From  750  To  755  DX= -1,100.000 mm.
RESTRAINTS
Node  755  +Y   Mu = .30
--------------------------------------------------------------------------------
From  755  To  760  DX= -2,765.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000
--------------------------------------------------------------------------------
From  760  To  765 DZ= 9,000.000 mm.
RESTRAINTS
Node  765  +Y   Mu = .30
Node  765  Z
--------------------------------------------------------------------------------
From  765  To  770 DZ= 2,287.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 769
Angle/Node @2= .00 768
--------------------------------------------------------------------------------
From  770  To  775  DX= -4,000.000 mm.
RESTRAINTS
Node  775  +Y   Mu = .30
--------------------------------------------------------------------------------
From  775  To  780  DX= -1,951.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 779
Angle/Node @2= .00 778
--------------------------------------------------------------------------------
```

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CAESAR  II   VERS 4.50                          APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

From  780  To  785 DZ= 10,200.000 mm.
RESTRAINTS
Node  785  +Y
Node  785  X
--------------------------------------------------------------------------------
From  785  To  788 DZ= 2,000.000 mm.
--------------------------------------------------------------------------------
From  788  To  790 DZ= 3,071.000 mm.
--------------------------------------------------------------------------------
From  790  To  800 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  800  ANC   Cnode  801
--------------------------------------------------------------------------------
From  801  To  810 DZ= 213.000 mm.
RIGID  Weight= 4,141.09 N.
--------------------------------------------------------------------------------
From  810  To  815  DX= 2,201.000 mm.  DZ= 2,883.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00 814
--------------------------------------------------------------------------------
From  815  To  830 DY= -1,492.000 mm.
--------------------------------------------------------------------------------
From  830  To  840 DY= -213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  840  ANC   Cnode  841
--------------------------------------------------------------------------------
From  170  To  175  DX= -2,200.000 mm.
RESTRAINTS
Node  175  +Y   Mu = .30
--------------------------------------------------------------------------------
From  175  To  1000  DX= -982.000 mm.
SIF's & TEE's
Node  1000   Welding Tee
--------------------------------------------------------------------------------
From  1000  To  1005 DZ= -1,200.000 mm.
--------------------------------------------------------------------------------
From  1005  To  1010 DZ= -859.000 mm.
--------------------------------------------------------------------------------
From  1010  To  1020 DZ= -213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  1020  ANC   Cnode  1021
--------------------------------------------------------------------------------
From  1021  To  1030 DZ= -2,400.000 mm.
RIGID  Weight=50,982.98 N.
RESTRAINTS
Node  1030  ANC   Cnode  1031
--------------------------------------------------------------------------------
From  1031  To  1040 DZ= -213.000 mm.
RIGID  Weight= 4,141.09 N.
--------------------------------------------------------------------------------
From  1040  To  1045 DZ= -550.000 mm.
--------------------------------------------------------------------------------
From  1045  To  1050 DZ= -450.000 mm.
--------------------------------------------------------------------------------
From  1050  To  1060 DZ= -610.000 mm.
REDUCER
Diam2= 609.600 mm.
--------------------------------------------------------------------------------
From  1060  To  1070 DZ= -171.450 mm.
PIPE
```

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CAESAR II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

Dia= 609.600 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
RIGID  Weight= 2,428.61 N.
RESTRAINTS
Node  1070  ANC   Cnode  1071
------------------------------------------------------------------------------
From  1071  To  1080 DZ= -1,500.000 mm.
RIGID  Weight=31,345.06 N.
RESTRAINTS
Node  1080  ANC   Cnode  1081
------------------------------------------------------------------------------
From  1081  To  1090 DZ= -171.450 mm.
RIGID  Weight= 2,428.61 N.
------------------------------------------------------------------------------
From  1090  To  1100 DZ= -610.000 mm.
REDUCER
Diam2= 762.000 mm.
------------------------------------------------------------------------------
From  1100  To  1105 DZ= -550.000 mm.
PIPE
Dia= 762.000 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
RESTRAINTS
Node  1105  +Y   Mu = .30
------------------------------------------------------------------------------
From  1105  To  1110 DZ= -450.000 mm.
------------------------------------------------------------------------------
From  1110  To  1120 DZ= -213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  1120  ANC   Cnode  1121
------------------------------------------------------------------------------
From  1121  To  1130 DZ= -2,400.000 mm.
RIGID  Weight=50,982.98 N.
RESTRAINTS
Node  1130  ANC   Cnode  1131
------------------------------------------------------------------------------
From  1131  To  1140 DZ= -213.000 mm.
RIGID  Weight= 4,141.09 N.
------------------------------------------------------------------------------
From  1140  To  1150 DZ= -1,643.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1149   Angle/Node @2= .00 1148
------------------------------------------------------------------------------
From  1150  To  1160 DY= -3,582.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1159   Angle/Node @2= .00 1158
------------------------------------------------------------------------------
From  1160  To  1165 DZ= 3,200.000 mm.
RESTRAINTS
Node  1165  +Y   Mu = .30
------------------------------------------------------------------------------
From  1165  To  1167 DZ= 7,000.000 mm.
RESTRAINTS
Node  1167  X
------------------------------------------------------------------------------
From  1167  To  1170 DZ= 4,216.900 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1169   Angle/Node @2= .00 1168
------------------------------------------------------------------------------
From  1170  To  1175  DX= -2,600.000 mm.
RESTRAINTS
```

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CAESAR  II   VERS 4.50                      APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

Node  1175   +Y    Mu = .30
Node  1175   Z
---------------------------------------------------------------------------
From  1175  To  1180  DX= -2,928.000 mm.
SIF's & TEE's
Node  1180   Welding Tee
---------------------------------------------------------------------------
From  1180  To  1190  DX= -2,717.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1189   Angle/Node @2= .00 1188
---------------------------------------------------------------------------
From  1190  To  1200 DY= -2,234.000 mm.
PIPE
Dia= 762.000 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
SIF's & TEE's
Node  1200   Weldolet
---------------------------------------------------------------------------
From  1000  To  1006  DX= -500.000 mm.
---------------------------------------------------------------------------
From  1006  To  1300  DX= -559.000 mm.
---------------------------------------------------------------------------
From  1300  To  1310  DX= -213.000 mm.
RIGID  Weight= 4,141.09 N.
RESTRAINTS
Node  1310  ANC   Cnode  1311
---------------------------------------------------------------------------
From  1311  To  1320  DX= -2,400.000 mm.
RIGID  Weight=50,982.98 N.
RESTRAINTS
Node  1320  ANC   Cnode  1321
---------------------------------------------------------------------------
From  1321  To  1330  DX= -213.000 mm.
RIGID  Weight= 4,141.09 N.
---------------------------------------------------------------------------
From  1330  To  1340  DX= -1,643.000 mm.
BEND at "TO" end
Radius= 1,143.000 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1339   Angle/Node @2= .00 1338
---------------------------------------------------------------------------
From  1340  To  1180 DY= -3,582.000 mm.
---------------------------------------------------------------------------
From  1200  To  1350 DZ= -1,596.000 mm.
PIPE
Dia= 914.400 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
GENERAL
T1= 27 C
ALLOWABLE STRESSES
B31.3 (2002)       Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa   Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa   Sh8= 137,892 KPa   Sh9= 137,892 KPa
---------------------------------------------------------------------------
From  1350  To  1400 DZ= -707.000 mm.
---------------------------------------------------------------------------
From  1400  To  1410 DZ= -610.000 mm.
REDUCER
Diam2= 1,066.800 mm.   Wall2= 12.700 mm.
---------------------------------------------------------------------------
From  1410  To  1415 DZ= -700.000 mm.
PIPE
Dia= 1,066.800 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
---------------------------------------------------------------------------
From  1415  To  1420 DZ= -171.000 mm.
```

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CAESAR  II   VERS 4.50                        APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

PIPE
Dia= 1,066.800 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
RIGID  Weight= 3,207.01 N.
RESTRAINTS
Node  1420  ANC
---------------------------------------------------------------------
From  1200  To  1250 DZ= 1,596.000 mm.
PIPE
Dia= 914.400 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
RESTRAINTS
Node  1250  +Y   Mu = .30
---------------------------------------------------------------------
From  1250  To  1500 DZ= 1,964.000 mm.
BEND at "TO" end
Radius= 1,371.600 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1499   Angle/Node @2= .00 1498
---------------------------------------------------------------------
From  1500  To  1510 DY= 5,316.000 mm.
BEND at "TO" end
Radius= 1,371.600 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1509   Angle/Node @2= .00 1508
---------------------------------------------------------------------
From  1510  To  1515 DZ= 10,200.000 mm.
RESTRAINTS
Node  1515  +Y   Mu = .30
---------------------------------------------------------------------
From  1515  To  1520 DZ= 1,652.000 mm.
BEND at "TO" end
Radius= 1,371.600 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1519   Angle/Node @2= .00 1518
---------------------------------------------------------------------
From  1520  To  1525  DX= 3,600.000 mm.
RESTRAINTS
Node  1525  Z
---------------------------------------------------------------------
From  1525  To  1530  DX= 5,012.000 mm.
BEND at "TO" end
Radius= 1,371.600 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1529   Angle/Node @2= .00 1528
---------------------------------------------------------------------
From  1530  To  1535 DZ= 4,072.000 mm.
RESTRAINTS
Node  1535  +Y   Mu = .30
---------------------------------------------------------------------
From  1535  To  1540 DZ= 2,797.000 mm.
BEND at "TO" end
Radius= 1,371.600 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1539   Angle/Node @2= .00 1538
---------------------------------------------------------------------
From  1540  To  1550 DY= 6,000.000 mm.
---------------------------------------------------------------------
From  1550  To  1555 DY= 6,000.000 mm.
RESTRAINTS
Node  1555  X
Node  1555  Z
---------------------------------------------------------------------
From  1555  To  1560 DY= 6,000.000 mm.
---------------------------------------------------------------------
From  1560  To  1565 DY= 6,000.000 mm.
---------------------------------------------------------------------
From  1565  To  1570 DY= 6,000.000 mm.
---------------------------------------------------------------------
From  1570  To  1575 DY= 6,000.000 mm.
```

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CAESAR  II   VERS 4.50                   APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

-------------------------------------------------------------------------
From  1575  To  1700 DY= 5,000.000 mm.
-------------------------------------------------------------------------
From  1700  To  1710 DY= 6,000.000 mm.
RESTRAINTS
Node  1700  X
Node  1700  Z
-------------------------------------------------------------------------
From  1710  To  1715 DY= 6,000.000 mm.
-------------------------------------------------------------------------
From  1715  To  1720 DY= 6,000.000 mm.
-------------------------------------------------------------------------
From  1720  To  1725 DY= 6,000.000 mm.
-------------------------------------------------------------------------
From  1725  To  1730 DY= 6,000.000 mm.
-------------------------------------------------------------------------
From  1730  To  1740 DY= 6,000.000 mm.
RESTRAINTS
Node  1740  X
Node  1740  Z
-------------------------------------------------------------------------
From  1740  To  2500 DY= 4,432.000 mm.
BEND at "TO" end
Radius= 1,371.600 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1549   Angle/Node @2= .00 1548
-------------------------------------------------------------------------
From  2500  To  2505  DX= -1,272.792 mm.  DZ= 1,272.792 mm.
HANGERS
Hanger Node = 2505   Hanger Table = 0.0   Available Space = .0000 mm.
Allowed Load Variation = 25.0000   Max Allowed Travel = 40.0000 mm.
No. Hangers = 2   Short Range Flag = -1   User Operating Load = .00 N.
Free Node = 0   Free Node = 0   Free Code = 0.0   Spring Rate = .00 N./mm.
Theoretical Cold Load = .00 N.
-------------------------------------------------------------------------
From  2505  To  2510  DX= -2,192.031 mm.  DZ= 2,192.031 mm.
BEND at "TO" end
Radius= 1,371.600 mm. (LONG)   Bend Angle= 90.000   Angle/Node @1= 45.00
1559   Angle/Node @2= .00 1558
-------------------------------------------------------------------------
From  2510  To  2520 DY= -1,500.000 mm.
-------------------------------------------------------------------------
From  2520  To  2530 DY= -210.000 mm.
RIGID  Weight= 2,317.41 N.
RESTRAINTS
Node  2530  ANC   Cnode  3500
-------------------------------------------------------------------------
From  341  To  1590 DY= -213.000 mm.
PIPE
Dia= 762.000 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
RIGID  Weight= 4,141.09 N.
-------------------------------------------------------------------------
From  1590  To  1600 DY= -257.000 mm.
RESTRAINTS
Node  1600  ANC   Cnode  1610
DISPLACEMENTS
Node  1610   DX1= -1.500 mm.   DY1= 2.000 mm.   DZ1= .000 mm.
DX2= -1.734 mm.   DY2= 2.312 mm.   DZ2= .000 mm.
-------------------------------------------------------------------------
From  841  To  1650 DY= -213.000 mm.
RIGID  Weight= 4,141.09 N.
-------------------------------------------------------------------------
From  1650  To  1660 DY= -257.000 mm.
RESTRAINTS
```

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CAESAR  II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

Node  1660  ANC   Cnode  1670
DISPLACEMENTS
Node  1670   DX1= -.150 mm.   DY1= 2.000 mm.   DZ1= .000 mm.   RX1= .000
RY1= .000   RZ1= .000   DX2= .173 mm.   DY2= 2.312 mm.   DZ2= .000 mm.
RX2= .000   RY2= .000   RZ2= .000
-----------------------------------------------------------------------
From  3500  To  3510 DY= -210.000 mm.
PIPE
Dia= 914.000 mm.   Wall= 12.700 mm.   Insul= 50.000 mm.
RIGID  Weight= 2,317.11 N.
-----------------------------------------------------------------------
From  3520  To  3530 DY= -315.000 mm.
RESTRAINTS
Node  3530  ANC   Cnode  3540
-----------------------------------------------------------------------
From  3540  To  3550 DY= -2,197.000 mm.
PIPE
Dia= 7,500.000 mm.   Wall= 45.000 mm.   Insul= 50.000 mm.   Cor= 3.0000 mm.
GENERAL
P1= .0000 KPa   PHyd= .0000 KPa
RIGID  Weight= .00 N.
-----------------------------------------------------------------------
From  3550  To  3800 DY= -30,127.998 mm.
RIGID  Weight= .00 N.
-----------------------------------------------------------------------
From  3800  To  3810 DY= -5,872.000 mm.
RIGID  Weight= .00 N.
-----------------------------------------------------------------------
From  3810  To  3900 DY= -14,128.000 mm.
RIGID  Weight= .00 N.
-----------------------------------------------------------------------
From  3900  To  3950 DY= -14,872.000 mm.
RIGID  Weight= .00 N.
-----------------------------------------------------------------------
From  3950  To  4500 DY= -17,178.000 mm.
RIGID  Weight= .00 N.
-----------------------------------------------------------------------
From  4500  To  4510 DY= -1,875.000 mm.
GENERAL
T1= 39 C   T2= 100 C
RIGID  Weight= .00 N.
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa    Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa   Sh9= 137,892 KPa
-----------------------------------------------------------------------
From  4510  To  5000 DY= -9,100.000 mm.
GENERAL
T1= 21 C   T2= 21 C
RIGID  Weight= .00 N.
RESTRAINTS
Node  5000  ANC
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa    Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa   Sh9= 137,892 KPa
-----------------------------------------------------------------------
From  3550  To  3560  DX= 2,651.650 mm.  DZ= -2,651.651 mm.
GENERAL
T1= 27 C   T2= 120 C
RIGID  Weight= .00 N.
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
```

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CAESAR  II   VERS 4.50                        APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

Sh3= 137,892 KPa    Sh4= 137,892 KPa    Sh5= 137,892 KPa    Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa    Sh9= 137,892 KPa
------------------------------------------------------------------------------
From  3560  To  1740  DX= 813.173 mm.  DZ= -813.173 mm.
GENERAL
T1= 21 C   T2= 21 C
RIGID  Weight= .00 N.
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa    Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa   Sh9= 137,892 KPa
------------------------------------------------------------------------------
From  3810  To  3820  DX= 2,651.650 mm.  DZ= -2,651.651 mm.
GENERAL
T1= 27 C   T2= 120 C
RIGID  Weight= .00 N.
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa    Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa   Sh9= 137,892 KPa
------------------------------------------------------------------------------
From  3820  To  1700  DX= 813.173 mm.  DZ= -813.173 mm.
GENERAL
T1= 21 C   T2= 21 C
RIGID  Weight= .00 N.
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa    Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa   Sh9= 137,892 KPa
------------------------------------------------------------------------------
From  3950  To  3960  DX= 2,651.650 mm.  DZ= -2,651.651 mm.
GENERAL
T1= 27 C   T2= 120 C
RIGID  Weight= .00 N.
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa    Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa   Sh9= 137,892 KPa
------------------------------------------------------------------------------
From  3960  To  1555  DX= 813.173 mm.  DZ= -813.173 mm.
GENERAL
T1= 21 C   T2= 21 C
RIGID  Weight= .00 N.
ALLOWABLE STRESSES
B31.3 (2002)        Sc= 137,892 KPa   Sh1= 137,892 KPa   Sh2= 137,892 KPa
Sh3= 137,892 KPa    Sh4= 137,892 KPa   Sh5= 137,892 KPa   Sh6= 137,892 KPa
Sh7= 137,892 KPa    Sh8= 137,892 KPa   Sh9= 137,892 KPa
```

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

LOAD CASE REPORT

CASE 1 (HGR) W

WEIGHT FOR HANGER LOADS

CASE 2 (HGR) W+D1+T1+P1

OPERATING FOR HANGER TRAVEL

CASE 3 (HYD) WW+HP+H

HYDRO TEST CASE

CASE 4 (OPE) W+D1+T1+P1+H

OPERATING CASE CONDITION 1

CASE 5 (OPE) W+D2+T2+P1+H

OPERATING CASE CONDITION 2

CASE 6 (OPE) W+D1+T1+P1+H+U1

CASE 7 (OPE) W+D1+T1+P1+H-U1

CASE 8 (OPE) W+D1+T1+P1+H+U2

CASE 9 (OPE) W+D1+T1+P1+H-U2

CASE 10 (OPE) W+D1+T1+P1+H+U3

CASE 11 (OPE) W+D1+T1+P1+H-U3

CASE 12 (OPE) W+D1+T1+P1+H+WIN1

CASE 13 (OPE) W+D1+T1+P1+H-WIN1

CASE 14 (OPE) W+D1+T1+P1+H+WIN2

CASE 15 (OPE) W+D1+T1+P1+H-WIN2

CASE 16 (SUS) W+P1+H

SUSTAINED CASE CONDITION 1

CASE 17 (EXP) L17=L4-L16

EXPANSION CASE CONDITION 1

CASE 18 (EXP) L18=L5-L16

EXPANSION CASE CONDITION 2

CASE 19 (OCC) L19=L6-L4

CASE 20 (OCC) L20=L7-L4

CASE 21 (OCC) L21=L8-L4

CASE 22 (OCC) L22=L9-L4

CASE 23 (OCC) L23=L10-L4

CASE 24 (OCC) L24=L11-L4

CASE 25 (OCC) L25=L12-L4

CASE 26 (OCC) L26=L13-L4

CASE 27 (OCC) L27=L14-L4

CASE 28 (OCC) L28=L15-L4

CASE 29 (OCC) L29=L16+L19

CASE 30 (OCC) L30=L16+L20

CASE 31 (OCC) L31=L16+L21

CASE 32 (OCC) L32=L16+L22

CASE 33 (OCC) L33=L16+L23

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CAESAR  II   VERS 4.50                       APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

CASE 34 (OCC) L34=L16+L24

CASE 35 (OCC) L35=L16+L25

CASE 36 (OCC) L36=L16+L26

CASE 37 (OCC) L37=L16+L27

CASE 38 (OCC) L38=L16+L28
```

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 4 (OPE) W+D1+T1+P1+H

	-----Translations(mm.)-----			-------Rotations(deg.)-------		
NODE	DX	DY	DZ	RX	RY	RZ
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20	0.000	0.081	0.000	0.0000	-0.0001	0.0000
28	0.046	1.093	-0.054	0.0012	-0.0208	-0.0014
29	-0.060	1.409	-0.036	0.0171	-0.0254	0.0008
30	-0.395	1.419	-0.490	0.0149	-0.0551	0.0204
35	-0.417	1.399	-0.546	0.0153	-0.0553	0.0205
40	-0.863	0.945	-1.732	0.0229	-0.0585	0.0238
50	-0.944	0.857	-1.949	0.0230	-0.0586	0.0239
51	-0.944	0.857	-1.949	0.0230	-0.0586	0.0239
60	-1.025	0.768	-2.167	0.0230	-0.0586	0.0239
65	-1.645	0.000	-3.856	0.0336	-0.0576	0.0326
69	-2.172	-1.153	-4.349	0.0479	-0.0246	0.0729
70	-2.326	-2.088	-4.104	0.0075	0.0192	0.0580
80	-2.190	-2.153	-3.958	0.0041	0.0207	0.0555
90	-2.113	-2.169	-3.877	0.0039	0.0207	0.0554
91	-2.113	-2.169	-3.877	0.0039	0.0207	0.0554
100	-2.080	-2.176	-3.842	0.0038	0.0208	0.0554
101	-2.080	-2.176	-3.842	0.0038	0.0208	0.0554
110	-1.199	-2.282	-2.931	0.0007	0.0213	0.0544
111	-1.199	-2.282	-2.931	0.0007	0.0213	0.0544
120	-1.119	-2.284	-2.850	0.0004	0.0213	0.0543
130	-0.797	-2.146	-2.541	-0.0194	0.0236	0.0490
140	-0.710	-2.074	-2.460	-0.0197	0.0236	0.0489
141	-0.710	-2.074	-2.460	-0.0197	0.0236	0.0489
150	0.287	-1.172	-1.549	-0.0227	0.0239	0.0480
151	0.287	-1.172	-1.549	-0.0227	0.0239	0.0480
160	0.376	-1.086	-1.468	-0.0229	0.0240	0.0479
165	1.301	0.000	-0.691	-0.0234	0.0271	0.0346
170	2.289	0.530	0.101	-0.0111	0.0207	0.0210
175	1.463	0.000	0.749	-0.0138	0.0115	0.0073
178	2.669	0.719	0.548	-0.0096	0.0156	0.0232
179	2.430	0.755	0.751	-0.0174	-0.0302	0.0217
180	1.892	0.607	0.279	-0.0233	-0.0433	0.0150
182	1.756	0.511	0.000	-0.0245	-0.0426	0.0148
185	0.888	-0.018	-1.588	-0.0321	-0.0376	0.0111
187	0.395	-0.242	-2.414	-0.0365	-0.0356	0.0093
188	0.376	-0.250	-2.445	-0.0366	-0.0356	0.0092
189	-0.089	-0.054	-2.731	-0.0445	-0.0234	-0.0026
190	-0.480	0.707	-2.542	-0.0560	-0.0152	-0.0066
194	-0.669	1.376	-1.911	-0.0509	-0.0076	-0.0026
195	-0.682	1.329	-1.236	-0.0248	-0.0041	0.0051
198	-0.604	1.019	-0.894	-0.0224	-0.0037	0.0055
200	-0.346	0.086	-0.096	-0.0136	-0.0025	0.0061
210	-0.286	-0.123	0.027	-0.0113	-0.0022	0.0060
215	0.015	0.000	0.000	-0.0091	0.0072	0.0041
220	0.489	0.000	-0.332	-0.0056	0.0217	0.0000
230	0.570	0.000	-0.413	-0.0056	0.0218	0.0000
231	0.570	0.000	-0.413	-0.0056	0.0218	0.0000
240	1.480	0.004	-1.359	-0.0051	0.0232	0.0001
241	1.480	0.004	-1.359	-0.0051	0.0232	0.0001
250	1.561	0.005	-1.445	-0.0051	0.0233	0.0001
255	1.976	0.000	-1.968	-0.0021	0.0300	-0.0056
260	3.146	-1.007	-2.952	0.0068	-0.0204	-0.0267
265	-0.612	0.000	0.000	-0.0204	-0.0276	-0.0142
268	-1.150	0.408	0.433	-0.0203	-0.0250	-0.0124
269	-1.123	0.625	0.735	-0.0196	0.0153	-0.0109
270	-0.641	0.602	0.321	-0.0187	0.0582	-0.0101
275	0.440	0.000	-2.776	-0.0142	0.0640	-0.0191
278	0.746	-0.320	-3.693	-0.0130	0.0637	-0.0238

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 4 (OPE) W+D1+T1+P1+H

	-----Translations(mm.)-----			-------Rotations(deg.)-------		
NODE	DX	DY	DZ	RX	RY	RZ
279	1.322	-0.928	-4.303	0.0000	0.0337	-0.0609
280	1.613	-1.372	-4.114	0.0025	-0.0083	-0.0669
285	0.000	0.000	-0.704	-0.0062	0.0028	-0.0881
288	0.289	-0.008	0.049	0.0032	0.0118	-0.0928
290	1.079	-0.272	1.205	0.0044	0.0144	-0.1000
300	1.132	-0.288	1.286	0.0043	0.0144	-0.1000
301	1.132	-0.288	1.286	0.0043	0.0144	-0.1000
310	1.186	-0.304	1.366	0.0043	0.0144	-0.1001
314	0.440	2.596	2.548	0.0477	0.0037	-0.0771
315	-0.532	2.241	1.644	0.0899	0.0007	-0.0545
330	-0.859	2.110	1.088	0.0908	0.0007	-0.0540
340	-1.059	2.029	0.750	0.0908	0.0007	-0.0540
341	-1.059	2.029	0.750	0.0908	0.0007	-0.0540
720	-1.060	-0.252	-0.439	-0.0057	-0.0222	-0.0026
730	-1.141	-0.242	-0.522	-0.0057	-0.0223	-0.0027
731	-1.141	-0.242	-0.522	-0.0057	-0.0223	-0.0027
740	-2.052	-0.105	-1.483	-0.0052	-0.0234	-0.0036
741	-2.052	-0.105	-1.483	-0.0052	-0.0234	-0.0036
750	-2.133	-0.091	-1.570	-0.0052	-0.0235	-0.0036
755	-2.546	0.000	-2.085	-0.0022	-0.0292	0.0007
760	-3.637	-0.749	-2.955	0.0071	0.0241	0.0213
765	0.433	0.000	0.000	-0.0156	0.0275	0.0094
768	0.961	0.299	0.432	-0.0145	0.0238	0.0077
769	0.822	0.414	0.672	-0.0087	-0.0309	0.0078
770	0.222	0.366	-0.064	-0.0072	-0.0865	0.0061
775	-0.858	0.000	-4.610	-0.0017	-0.0927	0.0129
778	-1.163	-0.226	-5.930	-0.0001	-0.0917	0.0164
779	-1.851	-0.691	-6.848	0.0084	-0.0478	0.0396
780	-2.223	-1.076	-6.711	0.0067	0.0098	0.0412
785	0.000	0.000	-3.307	-0.0095	-0.0003	0.0428
788	-0.235	0.172	-2.555	-0.0041	-0.0106	0.0432
790	-0.958	0.494	-1.400	-0.0108	-0.0122	0.0438
800	-1.003	0.534	-1.320	-0.0108	-0.0122	0.0438
801	-1.003	0.534	-1.320	-0.0108	-0.0122	0.0438
810	-1.049	0.574	-1.239	-0.0108	-0.0121	0.0438
814	-0.408	2.500	0.003	0.0001	0.0027	0.0258
815	-0.147	2.241	0.034	0.0019	-0.0010	0.0008
830	-0.148	2.110	0.017	0.0012	-0.0004	0.0002
840	-0.148	2.029	0.012	0.0012	-0.0004	0.0001
841	-0.148	2.029	0.012	0.0012	-0.0004	0.0001
1000	1.098	-0.111	0.909	-0.0150	0.0051	-0.0026
1005	0.992	-0.497	0.460	-0.0150	0.0051	-0.0037
1006	0.912	-0.062	0.931	-0.0127	0.0014	-0.0098
1010	0.914	-0.719	0.138	-0.0090	0.0052	-0.0044
1020	0.895	-0.753	0.057	-0.0089	0.0052	-0.0044
1021	0.895	-0.753	0.057	-0.0089	0.0052	-0.0044
1030	0.679	-1.083	-0.853	-0.0066	0.0052	-0.0045
1031	0.679	-1.083	-0.853	-0.0066	0.0052	-0.0045
1040	0.660	-1.107	-0.934	-0.0064	0.0052	-0.0046
1045	0.610	-1.121	-1.140	0.0014	0.0052	-0.0050
1050	0.569	-1.079	-1.308	0.0072	0.0052	-0.0054
1060	0.514	-0.941	-1.536	0.0168	0.0052	-0.0062
1070	0.498	-0.891	-1.601	0.0170	0.0052	-0.0062
1071	0.498	-0.891	-1.601	0.0170	0.0052	-0.0062
1080	0.361	-0.425	-2.170	0.0179	0.0052	-0.0063
1081	0.361	-0.425	-2.170	0.0179	0.0052	-0.0063
1090	0.346	-0.370	-2.235	0.0179	0.0052	-0.0064
1100	0.290	-0.155	-2.463	0.0150	0.0052	-0.0071
1105	0.239	0.000	-2.669	0.0101	0.0053	-0.0076

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 4 (OPE) W+D1+T1+P1+H

	-----Translations(mm.)-----			-------Rotations(deg.)-------		
NODE	DX	DY	DZ	RX	RY	RZ
1110	0.198	0.039	-2.841	0.0058	0.0053	-0.0080
1120	0.178	0.059	-2.922	0.0058	0.0053	-0.0080
1121	0.178	0.059	-2.922	0.0058	0.0053	-0.0080
1130	-0.042	0.290	-3.834	0.0057	0.0053	-0.0081
1131	-0.042	0.290	-3.834	0.0057	0.0053	-0.0081
1140	-0.062	0.311	-3.915	0.0057	0.0053	-0.0081
1148	-0.108	0.369	-4.105	0.0068	0.0052	-0.0086
1149	-0.241	0.458	-4.517	0.0207	0.0066	-0.0103
1150	-0.471	0.278	-4.936	0.0172	0.0085	-0.0163
1158	-0.849	-0.211	-5.312	0.0153	0.0083	-0.0171
1159	-1.094	-0.506	-5.235	-0.0088	0.0060	-0.0233
1160	-1.175	-0.415	-4.847	-0.0140	0.0032	-0.0254
1165	-1.061	0.000	-4.068	-0.0025	0.0031	-0.0269
1167	0.000	-1.240	-1.439	0.0045	0.0206	-0.0322
1168	1.387	-1.190	-0.285	-0.0042	0.0263	-0.0345
1169	1.499	-0.876	0.091	-0.0067	0.0048	-0.0347
1170	1.184	-0.438	0.157	-0.0004	-0.0064	-0.0188
1175	0.634	0.000	0.000	0.0026	-0.0022	-0.0121
1180	-0.463	0.248	0.162	0.0087	0.0030	-0.0029
1188	-1.041	0.660	0.253	0.0055	0.0028	-0.0163
1189	-1.364	0.691	0.231	0.0045	-0.0015	0.0094
1190	-1.074	0.260	0.195	-0.0011	-0.0019	0.0332
1200	-0.421	-0.139	0.227	-0.0016	-0.0040	0.0254
1250	-0.442	0.000	0.323	0.0000	-0.0014	0.0227
1300	0.705	0.070	0.921	-0.0103	-0.0022	-0.0182
1310	0.624	0.139	0.912	-0.0102	-0.0022	-0.0184
1311	0.624	0.139	0.912	-0.0102	-0.0022	-0.0184
1320	-0.286	0.961	0.804	-0.0095	-0.0027	-0.0204
1321	-0.286	0.961	0.804	-0.0095	-0.0027	-0.0204
1330	-0.367	1.038	0.793	-0.0094	-0.0027	-0.0205
1338	-0.553	1.251	0.763	-0.0072	-0.0028	-0.0224
1339	-0.967	1.451	0.742	-0.0020	-0.0033	-0.0099
1340	-0.987	1.145	0.647	0.0109	-0.0046	0.0160
1350	-0.200	-0.099	0.132	0.0020	-0.0068	0.0129
1400	-0.102	-0.058	0.090	0.0021	-0.0052	0.0073
1410	-0.040	-0.026	0.053	0.0014	-0.0031	0.0035
1415	-0.001	0.000	0.011	0.0000	-0.0001	0.0001
1420	0.000	0.000	0.000	0.0000	0.0000	0.0000
1498	-0.459	-0.042	0.361	0.0025	-0.0018	0.0216
1499	-0.655	-0.244	0.521	0.0101	-0.0024	0.0186
1500	-0.858	-0.200	0.475	-0.0187	0.0017	0.0033
1508	-0.927	-0.046	-0.441	-0.0196	0.0001	-0.0003
1509	-0.754	0.054	-0.585	0.0014	0.0046	-0.0167
1510	-0.523	-0.075	-0.475	0.0108	0.0050	-0.0203
1515	-0.017	0.000	0.088	-0.0091	0.0019	-0.0371
1518	-0.009	0.037	0.106	-0.0088	0.0018	-0.0376
1519	0.034	-0.152	0.164	-0.0069	0.0011	-0.0390
1520	0.110	-0.688	0.152	-0.0130	0.0037	-0.0287
1525	0.255	-1.744	0.000	-0.0187	0.0042	-0.0238
1528	0.493	-2.894	-0.282	-0.0280	0.0040	-0.0136
1529	0.553	-2.694	-0.271	-0.0378	-0.0030	0.0065
1530	0.469	-1.901	-0.170	-0.0426	-0.0091	0.0094
1535	0.027	0.000	0.007	-0.0318	-0.0090	0.0076
1538	-0.189	0.636	0.100	-0.0240	-0.0085	0.0067
1539	-0.332	0.778	0.147	0.0019	-0.0038	0.0039
1540	-0.364	0.818	0.207	-0.0006	-0.0014	-0.0020
1548	0.049	5.978	-0.049	-0.0018	0.0000	-0.0018
1549	0.124	6.113	-0.124	-0.0071	0.0000	-0.0071
1550	-0.161	1.114	0.104	-0.0015	-0.0008	-0.0025

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 4 (OPE) W+D1+T1+P1+H

	-----Translations(mm.)-----			-------Rotations(deg.)-------		
NODE	DX	DY	DZ	RX	RY	RZ
1555	0.000	1.523	0.000	0.0002	0.0000	0.0002
1558	0.011	5.435	-0.011	0.0157	0.0000	0.0157
1559	0.129	4.887	-0.129	0.0252	0.0000	0.0252
1560	-0.015	1.855	0.015	0.0001	0.0000	0.0001
1565	-0.018	2.216	0.018	0.0000	0.0000	0.0000
1570	-0.014	2.605	0.014	-0.0001	0.0000	-0.0001
1575	-0.006	3.023	0.006	-0.0001	0.0000	-0.0001
1590	-1.260	2.015	0.412	0.0908	0.0007	-0.0540
1600	-1.500	2.000	0.000	0.0909	0.0007	-0.0540
1610	-1.500	2.000	0.000	0.0909	0.0007	-0.0540
1650	-0.147	2.015	0.008	0.0011	-0.0004	0.0001
1660	-0.150	2.000	0.000	0.0000	0.0000	0.0000
1670	-0.150	2.000	0.000	0.0000	0.0000	0.0000
1700	0.000	3.394	0.000	-0.0001	0.0000	-0.0001
1710	0.004	3.718	-0.004	0.0000	0.0000	0.0000
1715	0.005	4.071	-0.005	0.0000	0.0000	0.0000
1720	0.004	4.452	-0.004	0.0000	0.0000	0.0000
1725	0.002	4.862	-0.002	0.0000	0.0000	0.0000
1730	0.001	5.300	-0.001	0.0000	0.0000	0.0000
1740	0.000	5.767	0.000	0.0000	0.0000	0.0000
2000	0.000	0.000	0.000	0.0000	0.0000	0.0000
2500	0.111	6.177	-0.111	0.0108	0.0000	0.0108
2505	0.091	6.070	-0.091	0.0120	0.0000	0.0120
2510	0.553	4.564	-0.553	0.0263	0.0000	0.0263
2520	0.612	4.555	-0.612	0.0263	0.0000	0.0263
2530	0.709	4.542	-0.709	0.0263	0.0000	0.0263
3500	0.709	4.542	-0.709	0.0263	0.0000	0.0263
3510	0.805	4.528	-0.805	0.0263	0.0000	0.0263
3520	-0.174	5.933	0.174	0.0000	0.0000	0.0000
3530	-0.174	5.912	0.174	0.0000	0.0000	0.0000
3540	-0.174	5.912	0.174	0.0000	0.0000	0.0000
3550	-0.174	5.768	0.174	0.0000	0.0000	0.0000
3560	0.000	5.767	0.000	0.0000	0.0000	0.0000
3800	-0.172	3.788	0.172	0.0000	0.0000	0.0000
3810	-0.175	3.402	0.175	0.0000	0.0000	0.0000
3820	0.000	3.396	0.000	-0.0001	0.0000	-0.0001
3900	-0.191	2.474	0.191	0.0000	0.0000	0.0000
3950	-0.173	1.498	0.173	0.0002	0.0000	0.0002
3960	0.000	1.517	0.000	0.0002	0.0000	0.0002
4500	-0.056	0.371	0.056	0.0003	0.0000	0.0003
4510	-0.044	-0.002	0.044	0.0003	0.0000	0.0003
5000	0.000	0.000	0.000	0.0001	0.0000	0.0001

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 16 (SUS) W+P1+H

	------Translations(mm.)------			------Rotations(deg.)-------		
NODE	DX	DY	DZ	RX	RY	RZ
10	0.000	0.000	0.000	0.0000	0.0000	0.0000
20	0.000	0.000	0.000	0.0000	0.0000	0.0000
28	0.068	0.005	0.127	0.0062	-0.0062	-0.0029
29	0.186	0.067	0.374	0.0296	-0.0013	-0.0120
30	0.253	0.204	0.540	0.0344	-0.0051	-0.0009
35	0.253	0.205	0.535	0.0346	-0.0051	-0.0008
40	0.253	0.196	0.412	0.0396	-0.0064	0.0025
50	0.253	0.186	0.388	0.0397	-0.0064	0.0026
51	0.253	0.186	0.388	0.0397	-0.0064	0.0026
60	0.253	0.177	0.364	0.0397	-0.0064	0.0026
65	0.253	0.000	0.165	0.0467	-0.0070	0.0132
69	0.215	-1.057	0.069	0.0616	-0.0056	0.0647
70	0.165	-2.078	0.044	0.0101	-0.0014	0.0493
80	0.156	-2.158	0.043	0.0060	-0.0012	0.0477
90	0.152	-2.181	0.043	0.0058	-0.0012	0.0476
91	0.152	-2.181	0.043	0.0058	-0.0012	0.0476
100	0.150	-2.191	0.043	0.0057	-0.0012	0.0476
101	0.150	-2.191	0.043	0.0057	-0.0012	0.0476
110	0.100	-2.369	0.043	0.0023	-0.0012	0.0469
111	0.100	-2.369	0.043	0.0023	-0.0012	0.0469
120	0.095	-2.377	0.043	0.0019	-0.0012	0.0469
130	0.081	-2.251	0.043	-0.0194	-0.0009	0.0434
140	0.078	-2.178	0.043	-0.0198	-0.0009	0.0433
141	0.078	-2.178	0.043	-0.0198	-0.0009	0.0433
150	0.043	-1.267	0.043	-0.0231	-0.0008	0.0426
151	0.043	-1.267	0.043	-0.0231	-0.0008	0.0426
160	0.040	-1.180	0.043	-0.0233	-0.0008	0.0426
165	0.024	0.000	0.042	-0.0283	-0.0001	0.0338
170	0.025	0.767	0.043	-0.0159	-0.0007	0.0247
175	0.028	0.000	-0.005	-0.0157	-0.0020	0.0196
178	0.005	1.039	0.044	-0.0130	-0.0010	0.0277
179	-0.012	1.002	0.038	-0.0098	-0.0012	0.0306
180	-0.020	0.625	0.016	-0.0121	-0.0027	0.0295
182	-0.020	0.439	0.000	-0.0130	-0.0028	0.0293
185	-0.021	-0.671	-0.134	-0.0182	-0.0038	0.0253
187	-0.021	-1.211	-0.224	-0.0212	-0.0041	0.0227
188	-0.021	-1.230	-0.227	-0.0213	-0.0041	0.0226
189	-0.055	-1.267	-0.303	-0.0298	-0.0063	0.0052
190	-0.147	-0.772	-0.341	-0.0385	-0.0060	0.0005
194	-0.215	-0.258	-0.140	-0.0289	-0.0039	0.0010
195	-0.213	-0.130	0.092	-0.0033	-0.0028	0.0024
198	-0.179	-0.127	0.124	-0.0012	-0.0023	0.0026
200	-0.040	-0.114	0.048	0.0046	-0.0007	0.0043
210	0.004	-0.110	-0.003	0.0059	-0.0003	0.0050
215	0.004	0.000	0.000	0.0070	-0.0002	0.0035
220	0.004	-0.006	0.002	0.0089	0.0000	0.0000
230	0.004	-0.007	0.002	0.0089	0.0000	0.0000
231	0.004	-0.007	0.002	0.0089	0.0000	0.0000
240	0.004	0.000	0.002	0.0091	0.0000	0.0002
241	0.004	0.000	0.002	0.0091	0.0000	0.0002
250	0.004	0.001	0.002	0.0091	0.0000	0.0002
255	0.004	0.000	0.001	0.0108	0.0000	-0.0053
260	0.005	-1.090	0.000	0.0077	0.0001	-0.0227
265	-0.002	0.000	0.000	-0.0204	-0.0003	-0.0134
268	-0.008	0.401	0.000	-0.0200	-0.0003	-0.0120
269	-0.014	0.603	0.003	-0.0184	-0.0004	-0.0111
270	-0.016	0.568	0.005	-0.0178	0.0003	-0.0099
275	-0.016	0.000	-0.024	-0.0143	0.0010	-0.0171
278	-0.016	-0.284	-0.042	-0.0133	0.0011	-0.0209

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 16 (SUS) W+P1+H

NODE	DX	DY	DZ	RX	RY	RZ
	------Translations(mm.)------			------Rotations(deg.)-------		
279	-0.018	-0.781	-0.046	-0.0032	-0.0014	-0.0506
280	-0.064	-1.096	-0.031	-0.0019	-0.0044	-0.0551
285	0.000	0.000	-0.036	0.0075	0.0112	-0.0716
288	0.509	-0.609	-0.038	0.0224	0.0172	-0.0752
290	1.599	-1.979	-0.039	0.0240	0.0222	-0.0809
300	1.682	-2.069	-0.039	0.0240	0.0222	-0.0809
301	1.682	-2.069	-0.039	0.0240	0.0222	-0.0809
310	1.765	-2.158	-0.039	0.0240	0.0222	-0.0809
314	2.334	-0.194	0.661	0.0186	0.0251	-0.0822
315	1.346	-0.003	0.447	0.0246	0.0260	-0.0750
330	0.891	-0.001	0.296	0.0247	0.0260	-0.0748
340	0.613	-0.001	0.204	0.0247	0.0260	-0.0748
341	0.613	-0.001	0.204	0.0247	0.0260	-0.0748
720	0.004	-0.229	-0.007	0.0088	0.0001	-0.0023
730	0.004	-0.221	-0.007	0.0088	0.0001	-0.0024
731	0.004	-0.221	-0.007	0.0088	0.0001	-0.0024
740	0.004	-0.096	-0.004	0.0091	0.0001	-0.0032
741	0.004	-0.096	-0.004	0.0091	0.0001	-0.0032
750	0.004	-0.083	-0.004	0.0091	0.0001	-0.0033
755	0.004	0.000	-0.002	0.0107	0.0001	0.0010
760	0.004	-0.861	0.000	0.0080	-0.0001	0.0178
765	0.000	0.000	0.000	-0.0163	0.0000	0.0088
768	0.001	0.308	0.000	-0.0150	0.0001	0.0075
769	0.004	0.421	0.001	-0.0085	0.0002	0.0081
770	0.004	0.365	0.002	-0.0073	-0.0001	0.0065
775	0.004	0.000	-0.011	-0.0026	-0.0005	0.0119
778	0.004	-0.206	-0.020	-0.0013	-0.0006	0.0149
779	0.002	-0.594	-0.028	0.0053	-0.0002	0.0329
780	0.009	-0.879	-0.027	0.0028	0.0010	0.0335
785	0.000	0.000	-0.029	0.0018	-0.0026	0.0327
788	-0.119	-0.328	-0.030	0.0123	-0.0038	0.0326
790	-0.323	-0.999	-0.031	0.0084	-0.0031	0.0323
800	-0.334	-1.030	-0.031	0.0083	-0.0031	0.0323
801	-0.334	-1.030	-0.031	0.0083	-0.0031	0.0323
810	-0.346	-1.061	-0.031	0.0083	-0.0031	0.0323
814	-0.220	-0.074	0.009	-0.0007	0.0029	0.0253
815	-0.012	-0.003	0.003	0.0002	-0.0010	0.0016
830	-0.006	-0.002	0.001	0.0001	-0.0005	0.0007
840	-0.003	-0.001	0.001	0.0001	-0.0004	0.0006
841	-0.003	-0.001	0.001	0.0001	-0.0004	0.0006
1000	0.030	-0.380	-0.046	-0.0156	-0.0027	0.0157
1005	0.068	-0.737	-0.045	-0.0125	-0.0011	0.0146
1006	0.031	-0.508	-0.075	-0.0149	-0.0036	0.0111
1010	0.077	-0.903	-0.044	-0.0050	-0.0002	0.0139
1020	0.077	-0.922	-0.044	-0.0048	-0.0001	0.0139
1021	0.077	-0.922	-0.044	-0.0048	-0.0001	0.0139
1030	0.080	-1.079	-0.044	-0.0026	0.0000	0.0138
1031	0.080	-1.079	-0.044	-0.0026	0.0000	0.0138
1040	0.080	-1.088	-0.044	-0.0024	0.0000	0.0138
1045	0.078	-1.064	-0.044	0.0046	0.0004	0.0133
1050	0.074	-0.997	-0.044	0.0094	0.0006	0.0129
1060	0.065	-0.842	-0.043	0.0168	0.0010	0.0122
1070	0.062	-0.792	-0.043	0.0169	0.0010	0.0122
1071	0.062	-0.792	-0.043	0.0169	0.0010	0.0122
1080	0.034	-0.335	-0.043	0.0172	0.0011	0.0120
1081	0.034	-0.335	-0.043	0.0172	0.0011	0.0120
1090	0.031	-0.282	-0.043	0.0171	0.0011	0.0120
1100	0.018	-0.096	-0.043	0.0100	0.0012	0.0113
1105	0.005	0.000	-0.042	0.0022	0.0012	0.0108

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 16 (SUS) W+P1+H

	Translations (mm.)			Rotations (deg.)		
NODE	DX	DY	DZ	RX	RY	RZ
1110	-0.004	-0.037	-0.043	-0.0046	0.0012	0.0104
1120	-0.009	-0.055	-0.043	-0.0047	0.0012	0.0104
1121	-0.009	-0.055	-0.043	-0.0047	0.0012	0.0104
1130	-0.060	-0.278	-0.043	-0.0053	0.0012	0.0103
1131	-0.060	-0.278	-0.043	-0.0053	0.0012	0.0103
1140	-0.065	-0.298	-0.043	-0.0053	0.0012	0.0102
1148	-0.075	-0.343	-0.043	-0.0050	0.0012	0.0098
1149	-0.047	-0.365	-0.042	0.0014	0.0029	0.0080
1150	0.003	-0.351	-0.075	0.0016	0.0048	0.0019
1158	0.037	-0.348	-0.108	0.0008	0.0047	0.0011
1159	0.028	-0.308	-0.046	-0.0095	0.0025	-0.0051
1160	0.004	-0.156	0.018	-0.0067	-0.0001	-0.0072
1165	-0.001	0.000	0.016	0.0029	-0.0001	-0.0088
1167	0.000	-1.113	0.016	-0.0014	0.0004	-0.0142
1168	0.031	-0.671	0.015	-0.0125	0.0006	-0.0166
1169	0.035	-0.307	0.016	-0.0192	0.0000	-0.0182
1170	0.034	-0.019	0.011	-0.0137	-0.0004	-0.0024
1175	0.034	0.000	0.000	-0.0112	-0.0003	0.0047
1180	0.037	-0.485	-0.026	-0.0064	-0.0015	0.0029
1188	0.042	-0.346	-0.067	-0.0052	-0.0014	-0.0075
1189	-0.051	-0.122	-0.052	-0.0044	-0.0008	-0.0141
1190	-0.127	-0.062	-0.019	-0.0010	-0.0014	0.0019
1200	-0.071	-0.054	-0.005	-0.0006	-0.0008	0.0015
1250	-0.073	0.000	-0.007	0.0032	-0.0006	0.0002
1300	0.032	-0.597	-0.117	-0.0140	-0.0046	0.0050
1310	0.032	-0.616	-0.134	-0.0140	-0.0046	0.0049
1311	0.032	-0.616	-0.134	-0.0140	-0.0046	0.0049
1320	0.032	-0.779	-0.329	-0.0137	-0.0047	0.0031
1321	0.032	-0.779	-0.329	-0.0137	-0.0047	0.0031
1330	0.032	-0.790	-0.347	-0.0137	-0.0047	0.0030
1338	0.033	-0.783	-0.389	-0.0129	-0.0046	0.0002
1339	-0.062	-0.582	-0.376	-0.0114	-0.0037	-0.0161
1340	-0.159	-0.509	-0.275	-0.0062	-0.0042	0.0035
1350	-0.033	-0.044	-0.002	0.0008	-0.0012	0.0008
1400	-0.016	-0.028	-0.002	0.0009	-0.0009	0.0004
1410	-0.006	-0.013	-0.001	0.0006	-0.0005	0.0002
1415	0.000	0.000	0.000	0.0000	0.0000	0.0000
1420	0.000	0.000	0.000	0.0000	0.0000	0.0000
1498	-0.082	-0.075	-0.008	0.0059	-0.0010	-0.0003
1499	-0.141	-0.409	0.141	0.0195	-0.0048	-0.0006
1500	-0.114	-0.507	0.274	-0.0046	-0.0036	-0.0076
1508	0.272	-0.522	-0.004	-0.0058	-0.0052	-0.0097
1509	0.505	-0.549	0.002	0.0074	-0.0026	-0.0201
1510	0.617	-0.723	0.070	0.0078	-0.0032	-0.0222
1515	0.007	0.000	0.056	-0.0129	-0.0037	-0.0339
1518	-0.011	0.056	0.056	-0.0124	-0.0036	-0.0343
1519	-0.042	-0.090	0.063	-0.0066	-0.0001	-0.0360
1520	-0.037	-0.562	0.048	-0.0125	0.0013	-0.0230
1525	-0.037	-1.381	0.000	-0.0167	0.0009	-0.0175
1528	-0.037	-2.106	-0.021	-0.0236	0.0001	-0.0068
1529	-0.038	-1.841	-0.019	-0.0312	0.0000	0.0108
1530	-0.032	-1.198	-0.021	-0.0285	0.0007	0.0111
1535	0.004	0.000	-0.020	-0.0159	0.0008	0.0091
1538	0.024	0.224	-0.021	-0.0076	0.0007	0.0080
1539	-0.015	0.084	0.061	0.0136	0.0014	0.0065
1540	-0.065	-0.002	0.210	0.0014	0.0029	0.0008
1548	0.110	0.001	-0.110	-0.0041	0.0000	-0.0041
1549	0.331	0.168	-0.331	-0.0198	0.0000	-0.0198
1550	-0.059	-0.015	0.160	-0.0018	0.0016	-0.0006

CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

DISPLACEMENT REPORT, Nodal Movements
CASE 16 (SUS) W+P1+H

NODE	DX (Translations (mm.))	DY	DZ	RX (Rotations (deg.))	RY	RZ
1555	0.000	-0.007	0.000	0.0000	0.0000	0.0000
1558	0.470	0.855	-0.470	-0.0029	0.0000	-0.0029
1559	0.503	0.781	-0.503	0.0065	0.0000	0.0065
1560	0.000	-0.063	0.000	0.0000	0.0000	0.0000
1565	0.000	-0.090	0.000	0.0000	0.0000	0.0000
1570	-0.001	-0.089	0.001	0.0000	0.0000	0.0000
1575	-0.001	-0.059	0.001	0.0000	0.0000	0.0000
1590	0.335	-0.001	0.112	0.0247	0.0260	-0.0748
1600	0.000	0.000	0.000	0.0248	0.0260	-0.0748
1610	0.000	0.000	0.000	0.0248	0.0260	-0.0748
1650	-0.001	-0.001	0.001	0.0001	-0.0004	0.0006
1660	0.000	0.000	0.000	0.0000	0.0000	0.0000
1670	0.000	0.000	0.000	0.0000	0.0000	0.0000
1700	0.000	-0.012	0.000	0.0000	0.0000	0.0000
1710	0.001	-0.083	-0.001	0.0000	0.0000	0.0000
1715	0.001	-0.126	-0.001	0.0000	0.0000	0.0000
1720	0.000	-0.140	0.000	0.0000	0.0000	0.0000
1725	0.000	-0.126	0.000	0.0000	0.0000	0.0000
1730	-0.001	-0.083	0.001	0.0000	0.0000	0.0000
1740	0.000	-0.012	0.000	0.0000	0.0000	0.0000
2000	0.000	0.000	0.000	0.0000	0.0000	0.0000
2500	0.470	0.601	-0.470	-0.0078	0.0000	-0.0078
2505	0.470	0.694	-0.470	-0.0066	0.0000	-0.0066
2510	0.630	0.706	-0.630	0.0076	0.0000	0.0076
2520	0.647	0.706	-0.647	0.0076	0.0000	0.0076
2530	0.675	0.706	-0.675	0.0076	0.0000	0.0076
3500	0.675	0.706	-0.675	0.0076	0.0000	0.0076
3510	0.703	0.706	-0.703	0.0076	0.0000	0.0076
3520	0.000	-0.010	0.000	0.0000	0.0000	0.0000
3530	0.000	-0.010	0.000	0.0000	0.0000	0.0000
3540	0.000	-0.010	0.000	0.0000	0.0000	0.0000
3550	0.000	-0.010	0.000	0.0000	0.0000	0.0000
3560	0.000	-0.011	0.000	0.0000	0.0000	0.0000
3800	0.000	-0.009	0.000	0.0000	0.0000	0.0000
3810	0.000	-0.008	0.000	0.0000	0.0000	0.0000
3820	0.000	-0.011	0.000	0.0000	0.0000	0.0000
3900	0.000	-0.007	0.000	0.0000	0.0000	0.0000
3950	0.000	-0.005	0.000	0.0000	0.0000	0.0000
3960	0.000	-0.006	0.000	0.0000	0.0000	0.0000
4500	0.000	-0.002	0.000	0.0000	0.0000	0.0000
4510	0.000	-0.002	0.000	0.0000	0.0000	0.0000
5000	0.000	0.000	0.000	0.0000	0.0000	0.0000

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CAESAR  II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY
               ---Forces(N. )--------Moments(N.m.  )-------Displacements(mm.)--
NODE CASE TYPE  FX        FY        FZ   MX        MY       MZ    DX        DY        DZ
10                      Rigid ANC
     3  HYD  460.  -32196. -3436.  13586. -14997. -640.  0.0000  0.0000  0.0000
     4  OPE  2184  -4629.  -13631.-17613. -44928. -7314. 0.0000  0.0000  0.0000
    16  SUS  59.    673.   -2945.  12770. -13379. -8197. 0.0000  0.0000  0.0000
MAX. 4       2184.  32196/3 13631  17613.  44928.  8197/160.000/160.000/3 0.0000

30                      Prog Design  VSH
     3  HYD  0.     6233.   0.       0.      0.      0.   -0.0009  0.0000  0.5887
     4  OPE  0.    -20772.  0.       0.      0.      0.   -0.3950  1.4189- 0.4900
    16  SUS  0.    -21112.  0.       0.      0.      0.    0.2527  0.2043  0.5398
MAX. 3       0.     21112/160.       0.      0.      0.    0.395/4 1.419/4 0.589

50                      Rigid ANC
     3  HYD -460.  -21707.  3436. -27375.  6101. -18442. -0.0008 0.0516  0.4174
     4  OPE -2184.-8872.    13631.-37087.  9638. -23873. -0.9438 0.8567 -1.9494
    16  SUS -59.   -13835.  2945. -24587.  5756. -27699.  0.2527 0.1864  0.3882
MAX. 4       2184.  21707.  13631. 37087.  9638.  27699/16 0.944  0.857   1.9494

65                      Rigid +Y
     3  HYD  0.    -132053. 0.       0.      0.      0.    -0.0007 0.0000  0.1678
     4  OPE  0.    -103545. 0.       0.      0.      0.    -1.6455 0.0000 -3.8564
    16  SUS  0.    -108924. 0.       0.      0.      0.     0.2527 0.0000  0.1652
MAX. 3       0.     132053. 0.       0.      0.      0.     1.645/40.0000 3.856/4

90                      Rigid ANC
     3  HYD -460.   74982.  3436.  120143.-3376.  26807. -0.0704-2.3458  0.0465
     4  OPE -2184.  68618.  13631. 95784. -27334. 37208. -2.1128-2.1690 -3.8767
    16  SUS -59.    69034.  2945.  109011.-2951.  24681.  0.1517-2.1810  0.0434
MAX. 4       2184   74982/3 13631  120143/327334. 37208.  2.113  2.346/3 3.8767

100                     Rigid ANC
     3  HYD -460.   66982.  3436.  126603.-3334.  26807. -0.0697-2.3566  0.0465
     4  OPE -2184.  60817.  13631. 101673.-27135. 37208. -2.0798-2.1756 -3.8421
    16  SUS -59.    61233.  2945.  114938.-2946.  24681.  0.1497-2.1906  0.0434
MAX. 4       2184.  66982/3 13631. 126603/327135  37208.  2.080  2.357/3 3.8421

110                     Rigid ANC
     3  HYD -460.   5449.  3436.  213521.-2229.  26807. -0.0520 -2.5592  0.0464
     4  OPE -2184.  4545.  13631. 180109.-21893. 37208. -1.1986 -2.2818 -2.9310
    16  SUS -59.    4961.  2945.  194373.-2803.  24681.  0.0996 -2.3693  0.0433
MAX. 4       2184.  5449/3 13631.213521/3 21893  37208.  1.1986  2.559/3 2.9310

140                     Rigid ANC
     3  HYD -460.  -10103. 3436.  210627. -1656.  26807. -0.0395 -2.3520  0.0459
     4  OPE -2184.-8280.   13631.177785. -19176. 37208. -0.7095 -2.0736 -2.4604
    16  SUS -59.   -7864.  2945.  192567. -2730.  24681.  0.0778 -2.1780  0.0429
MAX. 4       2184.10103/3 13631  210627/3 19176  37208   0.710   2.352/3 2.4604

150                     Rigid ANC
     3  HYD -460.  -71636. 3436.  112540. -551.   26807. -0.0108 -1.3593  0.0458
     4  OPE -2184.-64552.  13631.90386.  -13933. 37208.  0.2871 -1.1717 -1.5492
    16  SUS -59.   -64136. 2945.  106166. -2587.  24681.  0.0432 -1.2671  0.0428
MAX. 4       2184.71636/3 13631.112540/3 13933. 37208.  0.287   1.359/3 1.5492

165                     Rigid +
     3  HYD 3185.  -114465. 7809.   0.      0.     0.     0.0182  0.0000  0.0446
     4  OPE 29625  -111815.-15734   0.      0.     0.     1.3008  0.0000 -0.6909
    16  SUS 4277.  -95172.  7318.   0.      0.     0.     0.0244  0.0000  0.0418
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CAESAR  II   VERS 4.50                        APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY
                 ---Forces(N. )--------Moments(N.m.  )-------Displacements(mm.)--
NODE CASE TYPE  FX         FY       FZ    MX         MY        MZ    DX        DY         DZ
MAX.  3       29625/4 114465 15734/4 0.       0.        0.        1.301/4 0.0000 0.691/4

175                    Rigid +Y
      3  HYD 6311.  -135652.-1360.  0.       0.        0.        0.0360  0.0000 -0.0078
      4  OPE 21390  -80095.  10946. 0.       0.        0.        1.4633  0.0000  0.7488
     16  SUS 4868.  -104536.-950.   0.       0.        0.        0.0278  0.0000 -0.0054
MAX.  4         21390  135652/310946  0./3     0./3      0./ 3     1.4633  0.000/3 0.7488

182                    Rigid Z
      3  HYD 0.      0.      -4302.  0.       0.        0.       -0.0040  0.1556  0.0000
      4  OPE 0.      0.      38854.  0.       0.        0.        1.7562  0.5113  0.0000
     16  SUS 0.      0.      -4083.  0.       0.        0.       -0.0201  0.4386  0.0000
MAX.  4        0./ 3   0./ 3   38854  0./ 3    0./ 3     0./ 3     1.7562  0.5113  0.0000

215                    Rigid +Y Rigid Z
      3  HYD 641.   -124861. 649.   0.       0.        0.        0.0037  0.0000  0.0000
      4  OPE 2567.  -102425.-20623. 0.       0.        0.        0.0147  0.0000  0.0000
     16  SUS 755.   -101328. 568.   0.       0.        0.        0.0043  0.0000  0.0000
MAX.  4        2567. 124861/3 20623. 0./ 3   0./ 3     0./ 3     0.015   0.0000  0.0000

230                    Rigid ANC
      3  HYD 507.    21559.  169    -12201.-596.      3672.      0.0036  0.0119  0.0014
      4  OPE 20021   23822.  9964.  -15929.-77187.-306.          0.5696 -0.0004 -0.4130
     16  SUS 640.    23267.  230.   -8410. -842.     -3661.      0.0042 -0.0066  0.0019
MAX.  4        20021. 23822. 9964.   15929. 77187.   3672./3   0.570   0.012/3 0.4130

240                    Rigid ANC
      3  HYD 507.   -39973.  169.   -12201.-191.      25769.     0.0035  0.0243  0.0015
      4  OPE 20021  -32450.  9964.  -15929.-53275.    10047.     1.4805  0.0044 -1.3587
     16  SUS 640.   -33004.  230.   -8410. -290.      8023.      0.0042 -0.0001  0.0019
MAX.  4        20021. 39973/3 9964.  15929. 53275.   25769/3   1.4805  0.024/3 1.3587

255                    Rigid +Y
      3  HYD 603.   -97413.  209.   0.       0.        0.        0.0034  0.0000  0.0012
      4  OPE 15616.-73483.  -15560. 0.       0.        0.        1.9755  0.0000 -1.9684
     16  SUS 707.   -72722.  251.   0.       0.        0.        0.0040  0.0000  0.0014
MAX.  3       15616/4 97413.  15560/40.      0.        0.        1.976/4 0.0000 1.968/4

265                    Rigid +Y Rigid Z
      3  HYD-486.   -35629.  792.   0.       0.        0.       -0.0028  0.0000  0.0000
      4  OPE-5814.  -19380.  18247. 0.       0.        0.       -0.6122  0.0000  0.0000
     16  SUS-344.   -23481.  592.   0.       0.        0.       -0.0020  0.0000  0.0000
MAX.  4        5814.  35629/3 18247. 0./ 3   0./ 3     0./ 3     0.6122  0.000/3 0.0000

275                    Rigid +Y
      3  HYD-3798.  -64578.  -5775.  0.      0.        0.       -0.0217  0.0000 -0.0330
      4  OPE 2283.  -48627.  -14408. 0.      0.        0.        0.4399  0.0000 -2.7760
     16  SUS-2787.  -42851.  -4236.  0.      0.        0.       -0.0159  0.0000 -0.0242
MAX.  3        3798.  64578.  14408/40.      0.        0.        0.440/4 0.0000  2.78/4

285                    Rigid +Y Rigid X
                                     0.      0.        0.        0.0000  0.0000 -0.0494
      3  HYD 9843.  -88456.  0.     0.       0.        0.        0.0000  0.0000 -0.7043
      4  OPE 18361.-50050.   0.     0.       0.        0.        0.0000  0.0000 -0.0364
     16  SUS 7201.  -60806.  0.     0./ 3    0./ 3     0./ 3     0.0000  0.000/3 0.7043
MAX.  4        18361. 88456/3 0./ 3

300                    Rigid ANC
                                    21933.-6629.      13157.     2.3003 -2.8036 -0.0535
      3  HYD-5655.   5647.   4942.
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CAESAR II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY
              ---Forces(N. )--------Moments(N.m.  )-------Displacements(mm.)--
NODE CASE TYPE  FX        FY       FZ    MX        MY        MZ      DX        DY        DZ
      4  OPE-10634.-3926.    20464. 4793.   12117. 13496.   1.1324 -0.2878   1.2856
     16  SUS-4138.  3840.    3623.  17377.-4836.  10532.   1.6821 -2.0685 -0.0394
MAX.  4       10634. 5647/3  20464.21933/3 12117. 13496.   2.300/3 2.804/3 1.2856

340                Rigid ANC
      3  HYD-5655. -35049.  4942. -2323.  0.      -2658.    0.8382 -0.0018   0.2785
      4  OPE-10634.-33543.  20464.-9618.  0.      -4998.   -1.0595  2.0292   0.7498
     16  SUS-4138. -25776.  3623. -1703.  0.      -1945.    0.6127 -0.0014   0.2038
MAX.  4       10634. 35049/3 20464. 9618.  0./ 3   4998.    1.0595  2.0292   0.7498

730                Rigid ANC
      3  HYD 635.   7047.   -235.  -11955.-798.    52869.   0.0036 -0.2543 -0.0051
      4  OPE-23911. 10348.   7776. -15653. 62810. 52413.  -1.1411 -0.2419 -0.5215
     16  SUS 739.   11549. -318.   -8247. -1066.   49039.   0.0042 -0.2206 -0.0070
MAX.  4       23911. 11549/167776.  15653. 62810. 52869/3 1.1411  0.254/3 0.5215

740                Rigid ANC
      3  HYD 635.  -54486. -235.  -11955.-234.   -4058.    0.0036 -0.0957 -0.0030
      4  OPE-23911.-45924.  7776. -15653. 44148. 9721.    -2.0518 -0.1045 -1.4829
     16  SUS 739.  -44722. -318.   -8247. -303.   9231.     0.0042 -0.0963 -0.0041
MAX.  4       23911. 54486/3 7776.  15653. 44148. 9721.     2.0518  0.1045  1.4829

755                Rigid +Y
      3  HYD 605.  -110895.-248.    0.      0.      0.       0.0035  0.0000 -0.0014
      4  OPE-19975.-86062. -16358. 0.      0.      0.      -2.5462  0.0000 -2.0852
     16  SUS 715.  -83689. -347.    0.      0.      0.       0.0041  0.0000 -0.0020
MAX.  4       19975. 110895/316358. 0./ 3  0./ 3  0./ 3    2.5462  0.000/3 2.0852

765                Rigid +Y Rigid Z
      3  HYD 79.   -39189.  551.    0.      0.      0.       0.0005  0.0000  0.0000
      4  OPE 6830. -22766.  11973.  0.      0.      0.       0.4329  0.0000  0.0000
     16  SUS 65.   -26095.  432.    0.      0.      0.       0.0004  0.0000  0.0000
MAX.  4       6830.  39189/3 11973. 0./ 3  0./ 3  0./ 3    0.4329  0.000/3 0.0000

775                Rigid +Y
      3  HYD 1024. -64702. -2609.   0.      0.      0.       0.0058  0.0000 -0.0149
      4  OPE-2612. -47607. -14041.  0.      0.      0.      -0.8576  0.0000 -4.6097
     16  SUS 747.  -42923. -1945.   0.      0.      0.       0.0043  0.0000 -0.0111
MAX.  4       2612.  64702/3 14041. 0./ 3  0./ 3  0./ 3    0.8576  0.000/3 4.6097

785                Rigid +Y Rigid X
      3  HYD-4232. -84238.  0.      0.      0.      0.       0.0000  0.0000 -0.0391
      4  OPE-23280.-50300.  0.      0.      0.      0.       0.0000  0.0000 -3.3065
     16  SUS-3105. -57726.  0.      0.      0.      0.       0.0000  0.0000 -0.0294
MAX.  4       23280. 84238/3 0./ 3  0./ 3  0./ 3  0./ 3    0.0000  0.000/3 3.3065

800                Rigid ANC
      3  HYD 3159.  4082.   2071.  37479.-7745.   1940.   -0.4564 -1.3838 -0.0409
      4  OPE 13622.-2205.   24101. 26795.-19970.-1068.   -1.0035  0.5336 -1.3196
     16  SUS 2317.  2695.   1542.  28737.-5685.   490.    -0.3342 -1.0301 -0.0307
MAX.  4       13622. 4082/3  24101.37479/3 19970. 1940/3   1.0035  1.384/3 1.3196

840                Rigid ANC
      3  HYD 3159. -36614.  2071.  3483. -12968. 25454. -0.0044 -0.0019  0.0014
      4  OPE 13622.-31821.  24101. 23914.-9098.  8543.   -0.1476  2.0292  0.0124
     16  SUS 2317. -26921.  1542.  2565. -9465.  18591. -0.0032 -0.0014  0.0010
MAX.  4       13622. 36614/3 24101. 23914.12968/3 25454/3 0.1476 2.0292  0.0124
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CAESAR II VERS 4.50 APR 30,2008 18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY

NODE	CASE	TYPE	FX (Forces N.)	FY	FZ	MX (Moments N.m.)	MY	MZ	DX (Displacements mm.)	DY	DZ
1020		Rigid ANC									
	3	HYD	1693.	38806.	-4195.	-98426.	-9581.	5047.	0.0919	-1.0013	-0.0557
	4	OPE	22.	41975.	-32258.	-81962.	-308.	4994.	0.8953	-0.7532	0.0575
	16	SUS	1070.	34971.	-3766.	-90296.	-7793.	4906.	0.0773	-0.9217	-0.0444
MAX.	4		1693/3	41975.	32258.	98426/3	9581/3	5047/3	0.8953	1.001/3	0.0557
1030		Rigid ANC									
	3	HYD	1693.	-22727.	-4195.	-117721	-5519.	5047.	0.0893	-1.1782	-0.0555
	4	OPE	22.	-14296.	-32258.	-115177	-254.	4994.	0.6790	-1.0833	-0.8530
	16	SUS	1070.	-21301.	-3766.	-106701	-5226.	4906.	0.0801	-1.0792	-0.0442
MAX.	3		1693.	22727.	32258/4	117721	5519.	5047.	0.679/4	1.1782	0.853/4
1070		Rigid ANC									
	3	HYD	1693.	-40699.	-4195.	-52418.	-2143.	5047.	0.0661	-0.8621	-0.0544
	4	OPE	22.	-28293.	-32258.	-70942.	-210.	4994.	0.4982	-0.8906	-1.6015
	16	SUS	1070.	-35297.	-3766.	-48497.	-3092.	4906.	0.0615	-0.7915	-0.0432
MAX.	4		1693/3	40699/3	32258	70942.	3092/16	5047/3	0.4982	0.8921/3	1.6015
1080		Rigid ANC									
	3	HYD	1693.	-76252.	-4195.	35295.	397.	5047.	0.0378	-0.3606	-0.0542
	4	OPE	22.	-61777.	-32258.	-3390.	-177.	4994.	0.3614	-0.4247	-2.1704
	16	SUS	1070.	-68781.	-3766.	29563.	-1487.	4906.	0.0338	-0.3346	-0.0431
MAX.	4		1693/3	76252/3	32258.	35295/3	1487/16	5047/3	0.3614	0.4247	2.1704
1105		Rigid +Y									
	3	HYD	2404.	-165403.	-9349.	0.	0.	0.	0.0137	0.0000	-0.0534
	4	OPE	3497.	-130467.	-38983.	0.	0.	0.	0.2395	0.0000	-2.6695
	16	SUS	957.	-146315.	-7408.	0.	0.	0.	0.0055	0.0000	-0.0423
MAX.	4		3497.	165403/3	38983.	0./ 3	0./ 3	0./ 3	0.2395	0.0000	2.6695
1120		Rigid ANC									
	3	HYD	-711.	71179.	5153.	93584.	2179.	5047.	0.0061	-0.0720	-0.0538
	4	OPE	189.	54693.	6619.	45516.	-22.	4994.	0.1785	0.0593	-2.9218
	16	SUS	113.	63537.	3643.	81931.	12.	4906.	-0.0088	-0.0554	-0.0426
MAX.	3		711.	71179.	6619/4	93584.	2179	5047.	0.1785/4	0.0720	2.9218/4
1130		Rigid ANC									
	3	HYD	-711.	9647.	5153.	-3408.	473.	5047.	-0.0193	-0.3595	-0.0540
	4	OPE	189.	-1579.	6619.	-18221.	430.	4994.	-0.0421	0.2900	-3.8337
	16	SUS	113.	7265.	3643.	-3032.	283.	4906.	-0.0602	-0.2779	-0.0427
MAX.	3		711.	9647.	6619/4	18221/4	473.	5047.	0.060/16	0.3595	3.8337
1165		Rigid +Y									
	3	HYD	-1215.	-88563.	4118.	0.	0.	0.	-0.0069	0.0000	0.0235
	4	OPE	-5281.	-69720.	-20238.	0.	0.	0.	-1.0615	0.0000	-4.0677
	16	SUS	-88.	-59618.	2874.	0.	0.	0.	-0.0005	0.0000	0.0164
MAX.	4		5281.	88563/3	20238.	0./ 3	0./ 3	0./ 3	1.0615	0.0000/3	4.0677
1167		Rigid X									
	3	HYD	1299.	0.	0.	0.	0.	0.	0.0000	-1.7898	0.0223
	4	OPE	20863.	0.	0.	0.	0.	0.	0.0000	-1.2395	-1.4394
	16	SUS	707.	0.	0.	0.	0.	0.	0.0000	-1.1126	0.0155
MAX.	4		20863.	0./ 3	0./ 3	0./ 3	0./ 3	0./ 3	0.0000	1.790/3	1.4394
1175		Rigid Z Rigid +Y									
	3	HYD	8714.	-106169.	4274.	0.	0.	0.	0.0498	0.0000	0.0000
	4	OPE	15782.	-52605.	45536.	0.	0.	0.	0.6343	0.0000	0.0000
	16	SUS	5949.	-75163.	3531.	0.	0.	0.	0.0340	0.0000	0.0000

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CAESAR  II    VERS 4.50                    APR 30,2008   18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY
         ---Forces(N. )--------Moments(N.m.    )-------Displacements(mm.)--
NODE CASE TYPE   FX       FY      FZ   MX        MY       MZ    DX       DY       DZ
MAX.  4        15782. 106169/345536. 0./ 3   0./ 3   0./ 3   0.6343   0.0000   0.0000

1250               Rigid +Y
      3  HYD-16645.-187028.-1898.  0.        0.       0.      -0.0950  0.0000 -0.0108
      4  OPE-35312.-145834. 25830. 0.        0.       0.      -0.4420  0.0000  0.3233
     16  SUS-12793.-126193.-1208.  0.        0.       0.      -0.0731  0.0000 -0.0069
MAX.  4        35312. 187028/325830. 0./ 3   0./ 3   0./ 3   0.4420  0.000/3 0.3233

1310               Rigid ANC
      3  HYD-13432. 18943.   4901. -9173.    13505.  95456.   0.0403 -0.6711 -0.1671
      4  OPE-49691. 2633.    13779.-25688.   40591.  115451.  0.6239  0.1385  0.9124
     16  SUS-12408. 16108.   3945. -8931.    10271.  90412.   0.0318 -0.6162 -0.1340
MAX.  4        49691. 18943/3 13779. 25688.  40591.  115451.  0.6239  0.671/3 0.9124

1320               Rigid ANC
      3  HYD-13432.-42590.   4901. -9173.    1741.   67079.   0.0408 -0.8674 -0.4125
      4  OPE-49691.-53639.   13779.-25688.   7521.   54244.  -0.2860  0.9609  0.8036
     16  SUS-12408.-40164.   3945. -8931.    803.    61545.   0.0323 -0.7790 -0.3292
MAX.  4        49691. 53639.  13779. 25688.  7521.   67079/3  0.2860  0.9601  0.8036

1420               Rigid ANC
      3  HYD-7760. -33466. -15101. 33467.-21178. 3864.        0.0000  0.0000  0.0000
      4  OPE-45203.-43422. -45728. 61700.-111985.79031.       0.0000  0.0000  0.0000
     16  SUS-7000. -26835. -9575.  30128.-18207. 4751.        0.0000  0.0000  0.0000
MAX.  4        45203. 43422.  45728. 61700. 111985.79031.     0.0000  0.0000  0.0000

1515               Rigid +Y
      3  HYD 1870. -95204.  15144. 0.        0.       0.       0.0107  0.0000  0.0865
      4  OPE-3060. -60739.  15415. 0.        0.       0.      -0.0175  0.0000  0.0880
     16  SUS 1172. -61426.  9768.  0.        0.       0.       0.0067  0.0000  0.0558
MAX.  4        3060.  95204/3 15415. 0./ 3   0./ 3   0./ 3    0.0175  0.000/3 0.0880

1525               Rigid Z
      3  HYD 0.     0.      5377.  0.        0.       0.      -0.0629 -2.1422  0.0000
      4  OPE 0.     0.     -2843.  0.        0.       0.       0.2553 -1.7435  0.0000
     16  SUS 0.     0.      3362.  0.        0.       0.      -0.0372 -1.3805  0.0000
MAX.  3        0.     0.      5377.  0.        0.       0.       0.255/4 2.1422  0.0000

1535               Rigid +Y
      3  HYD 1105. -154744.-5539.  0.        0.       0.       0.0063  0.0000 -0.0316
      4  OPE 4775. -91826.  1206.  0.        0.       0.       0.0273  0.0000  0.0069
     16  SUS 737.  -99769. -3535.  0.        0.       0.       0.0042  0.0000 -0.0202
MAX.  3        4775/4 154744. 5539.  0.        0.       0.       0.0273  0.0000  0.0316

1555               Rigid Z Rigid X
      3  HYD-20684. 0.      22568. 0.        0.       0.       0.0000 -0.0109  0.0000
      4  OPE 802370.0.     -802464.0.        0.       0.       0.0000  1.5225  0.0000
     16  SUS-13567. 0.      14777. 0.        0.       0.       0.0000 -0.0069  0.0000
MAX.  4        802370.0./ 3 802464.0./ 3   0./ 3   0./ 3    0.0000  1.5225  0.0000

1600               Rigid ANC
      3  HYD-5655. -41823.  4942.  0.        0.       0.       0.0000  0.0000  0.0000
      4  OPE-10634.-39286.  20464. 0.        0.       0.      -1.5000  2.0000  0.0000
     16  SUS-4138. -31519.  3623.  0.        0.       0.       0.0000  0.0000  0.0000
MAX.  4        10634.41823/3 20464. 0.       0./16    0./ 3    1.5000  2.0000  0.0000

1610               Displ. Reaction
      3  HYD-5655. -41823.  4942.  0.        0.       0.       0.0000  0.0000  0.0000
      4  OPE-10634.-39286.  20464. 0.        0.       0.      -1.5000  2.0000  0.0000
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CAESAR  II   VERS 4.50                    APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

RESTRAINT-DISPLACEMENT REPORT, Loads on Restraints
RESTRAINT SUMMARY
                ---Forces(N. )--------Moments(N.m.  )-------Displacements(mm.)--
NODE CASE TYPE  FX        FY       FZ    MX        MY        MZ     DX        DY        DZ
     16  SUS-4138. -31519.  3623.  0.       0.       0.        0.0000   0.0000   0.0000
MAX.  4      10634. 41823/3 20464  0./ 3    0./ 3    0./ 3     1.5000   2.0000   0.0000

1660                    Rigid ANC
      3  HYD 3159. -43387.   2071.  4457. -12968. 23969.   0.0000   0.0000   0.0000
      4  OPE 13622.-37564.   24101. 35242.-9098.  2140.   -0.1500   2.0000   0.0000
     16  SUS 2317.  -32664.  1542.  3289.  -9465.  17502.   0.0000   0.0000   0.0000
MAX.  4      13622. 43387/3 24101. 35242.12968/3 23969/3 0.1500   2.0000   0.0000

1670                    Displ. Reaction
      3  HYD 3159. -43387.   2071.  4457. -12968. 23969.   0.0000   0.0000   0.0000
      4  OPE 13622.-37564.   24101. 35242.-9098.  2140.   -0.1500   2.0000   0.0000
     16  SUS 2317.  -32664.  1542.  3289.  -9465.  17502.   0.0000   0.0000   0.0000
MAX.  4      13622. 43387/3 24101. 35242. 12968/323969/3 0.1500   2.0000   0.0000

1700                    Rigid Z Rigid X
                                  0.        0.       0.        0.0000  -0.0188   0.0000
      3  HYD 1381.  0.       -1501. 0.       0.       0.        0.0000   3.3937   0.0000
      4  OPE-271540 0.        271568.0.       0.       0.        0.0000  -0.0119   0.0000
     16  SUS 1905.  0.       -1982.  0.       0./ 3    0./ 3     0.0000   3.3937   0.0000
MAX.  4      271540.0./ 3  271568. 0./ 3

1740                    Rigid Z Rigid X
                                  0.        0.       0.        0.0000  -0.0193   0.0000
      3  HYD 28464. 0.       -28459. 0.      0.       0.        0.0000   5.7671   0.0000
      4  OPE 41182. 0.       -41184. 0.      0.       0.        0.0000  -0.0118   0.0000
     16  SUS 17539. 0.       -17536. 0.      0./ 3    0./ 3     0.0000   5.7671   0.0000
MAX.  4      41182. 0./ 3   41184.  0./ 3

2000                    Displ. Reaction
                                                             0.0000   0.0000   0.0000
      3  HYD 460.   -32196. -3436.  13586.-14997.-640.      0.0000   0.0000   0.0000
      4  OPE 2184.  -4629.  -13631.-17613.-44928.-7314.     0.0000   0.0000   0.0000
     16  SUS 59.     673.   -2945.  12770.-13379.-8197.     0.0000   0.0000   0.0000
MAX.  4      2184.  32196/3 13631. 17613. 44928. 8197/16  0.0/16   0.00/3   0.0000

2505                    Prog Design  VSH
                                  0.        0.       0.        0.2543   0.0000  -0.2543
      3  HYD 0.     -110973. 0.      0.       0.       0.        0.0910   6.0704  -0.0910
      4  OPE 0.     -75407.  0.      0.       0.       0.        0.4703   0.6942  -0.4703
     16  SUS 0.     -82939.  0.      0./ 3    0./ 3    0./ 3     0.4703   6.07/4   0.4703
MAX. 16      0./ 3  110973/30./ 3

2530                    Rigid ANC
                                  0.        0.       0.        1.3400  -2.0334  -1.3400
      3  HYD 0.      3648.   0.      0.       0.       0.        0.7086   4.5415  -0.7086
      4  OPE 0.      2978.   0.      0.       0.       0.        0.6750   0.7061  -0.6750
     16  SUS 0.      2978.   0.      0./ 3    0./ 3    0./ 3     1.34/3   4.542/4  1.34/3
MAX.         0./ 3  3648./ 30./ 3

3530                    Rigid ANC
                                  0.        0.       0.       0.0006  -0.0156  -0.0006
      3  HYD 0.     -2832.   0.      0.       0.       0.      -0.1745   5.9125   0.1744
      4  OPE 0.     -1827.   0.      0.       0.       0.       0.0004  -0.0097  -0.0003
     16  SUS 0.     -1827.   0.      0./3     0./4     0./3     0.174/4  5.912/4  0.174/4
MAX.         0./ 3  2832./3 0./3

5000                    Rigid ANC
      3  HYD-10672.-612890. 11071. 63167. 2923.   59286. 0.0000   0.0000   0.0000
      4  OPE-573423-400018. 573312.9547096-915.   95481950.0000   0.0000   0.0000
     16  SUS-6857. -385308. 7113.  40603. 1875.   38114. 0.0000   0.0000   0.0000
MAX.  4      573423.612890/3573312 95470962923/3 95481950.0000   0.00/3   0.0000
```

```
CAESAR  II   VERS 4.50                        APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line
```

STRESS SUMMARY

PIPING CODE: B31.3 -2002, April 30, 2002

```
CASE 3 (HYD) WW+HP+H
****             CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:51.5  @NODE  1180   STRESS:94445.7   ALLOWABLE:   183396.
BENDING STRESS:           52450.7  @NODE  1180
TORSIONAL STRESS:          2572.0  @NODE    29
AXIAL STRESS:             60399.7  @NODE  1410
HOOP  STRESS:            122999.7  @NODE  1410
3D MAX INTENSITY:        127518.2  @NODE  1410

CASE 16 (SUS) W+P1+H
****             CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:63.5  @NODE  1000   STRESS:87599.8   ALLOWABLE:   137892.
BENDING STRESS:           55503.7  @NODE  1000
TORSIONAL STRESS:          2604.3  @NODE    29
AXIAL STRESS:             45872.4  @NODE  1410
HOOP  STRESS:             93249.9  @NODE  1410
3D MAX INTENSITY:         96261.5  @NODE  1410

CASE 17 (EXP) L17=L4-L16
****             CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:21.6  @NODE  1200   STRESS:65345.3   ALLOWABLE:   302402.
BENDING STRESS:           65297.0  @NODE  1200
TORSIONAL STRESS:          4643.2  @NODE  1350
AXIAL STRESS:              2261.3  @NODE  1189
HOOP  STRESS:                 0.0  @NODE    20
3D MAX INTENSITY:         75399.3  @NODE  1200

CASE 18 (EXP) L18=L5-L16
****             CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:68.8  @NODE   210   STRESS:208866.7  ALLOWABLE:   303707.
BENDING STRESS:          208851.2  @NODE   210
TORSIONAL STRESS:         10972.1  @NODE    28
AXIAL STRESS:              3975.1  @NODE  1189
HOOP  STRESS:                 0.0  @NODE    20
```

```
CAESAR  II   VERS 4.50                        APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

3D MAX INTENSITY:       237219.0  @NODE   210


CASE 29 (OCC) L29=L16+L19
****            CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:87.8  @NODE  1180   STRESS:161111.3   ALLOWABLE:   183396.
BENDING STRESS:          130625.1  @NODE  1180
TORSIONAL STRESS:          6113.8  @NODE  1350
AXIAL STRESS:             46012.0  @NODE  1410
HOOP  STRESS:             93249.9  @NODE  1410
3D MAX INTENSITY:        187930.4  @NODE  1180


CASE 30 (OCC) L30=L16+L20
****            CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:72.8  @NODE  1000   STRESS:133455.3   ALLOWABLE:   183396.
BENDING STRESS:          100703.8  @NODE  1000
TORSIONAL STRESS:          3172.6  @NODE  1250
AXIAL STRESS:             46320.5  @NODE  1410
HOOP  STRESS:             93249.9  @NODE  1410
3D MAX INTENSITY:        134684.3  @NODE  1000


CASE 31 (OCC) L31=L16+L21
****            CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:54.5  @NODE  1000   STRESS:99984.6   ALLOWABLE:   183396.
BENDING STRESS:           67639.9  @NODE  1000
TORSIONAL STRESS:          2990.4  @NODE    29
AXIAL STRESS:             46091.7  @NODE  1410
HOOP  STRESS:             93249.9  @NODE  1410
3D MAX INTENSITY:        101211.9  @NODE  1000


CASE 32 (OCC) L32=L16+L22
****            CODE STRESS CHECK PASSED
HIGHEST STRESSES: (KPa)
CODE STRESS %:53.3  @NODE  1000   STRESS:97781.4   ALLOWABLE:   183396.
BENDING STRESS:           65615.0  @NODE  1000
TORSIONAL STRESS:          3013.2  @NODE    29
AXIAL STRESS:             45908.8  @NODE  1410
HOOP  STRESS:             93249.9  @NODE  1410
3D MAX INTENSITY:         99009.0  @NODE  1000
```

```
CAESAR  II   VERS 4.50                          APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

CASE 33 (OCC) L33=L16+L23
****             CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:70.8  @NODE  1000    STRESS:129798.6   ALLOWABLE:    183396.
BENDING STRESS:            97396.1   @NODE  1000
TORSIONAL STRESS:           4347.0   @NODE  1006
AXIAL STRESS:              46396.1   @NODE  1415
HOOP  STRESS:              93249.9   @NODE  1410
3D MAX INTENSITY:         131062.0   @NODE  1000

CASE 34 (OCC) L34=L16+L24
****             CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:71.3  @NODE  1000    STRESS:130851.8   ALLOWABLE:    183396.
BENDING STRESS:            98544.5   @NODE  1000
TORSIONAL STRESS:           4178.1   @NODE  1006
AXIAL STRESS:              46124.0   @NODE  1415
HOOP  STRESS:              93249.9   @NODE  1410
3D MAX INTENSITY:         132111.7   @NODE  1000

CASE 35 (OCC) L35=L16+L25
****             CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:47.8  @NODE  1000    STRESS:87599.8   ALLOWABLE:    183396.
BENDING STRESS:            55503.7   @NODE  1000
TORSIONAL STRESS:           2604.3   @NODE    29
AXIAL STRESS:              45872.4   @NODE  1410
HOOP  STRESS:              93249.9   @NODE  1410
3D MAX INTENSITY:          96261.5   @NODE  1410

CASE 36 (OCC) L36=L16+L26
****             CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:47.8  @NODE  1000    STRESS:87599.8   ALLOWABLE:    183396.
BENDING STRESS:            55503.7   @NODE  1000
TORSIONAL STRESS:           2604.3   @NODE    29
AXIAL STRESS:              45872.4   @NODE  1410
HOOP  STRESS:              93249.9   @NODE  1410
3D MAX INTENSITY:          96261.5   @NODE  1410
```

```
CAESAR  II   VERS 4.50                         APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line
```

CASE 37 (OCC) L37=L16+L27

```
****            CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:48.7  @NODE  1000   STRESS:89332.0   ALLOWABLE:    183396.
BENDING STRESS:           57204.1  @NODE  1000
TORSIONAL STRESS:          2622.6  @NODE    29
AXIAL STRESS:             45951.6  @NODE  1410
HOOP  STRESS:             93249.9  @NODE  1410
3D MAX INTENSITY:         96697.6  @NODE  1415
```

CASE 38 (OCC) L38=L16+L28

```
****            CODE STRESS CHECK PASSED

HIGHEST STRESSES: (KPa)
CODE STRESS %:49.9  @NODE  1000   STRESS:91545.2   ALLOWABLE:    183396.
BENDING STRESS:           59409.0  @NODE  1000
TORSIONAL STRESS:          2627.1  @NODE    29
AXIAL STRESS:             45938.7  @NODE  1410
HOOP  STRESS:             93249.9  @NODE  1410
3D MAX INTENSITY:         96546.8  @NODE  1415
```

```
CAESAR  II   VERS 4.50                       APR 30,2008  18:52:38
Job name: Compressor Station Piping Stress Analysis - Discharge Line

HANGER REPORT
(TABLE DATA FROM DESIGN RUNS)
                                           THEORETICAL   ACTUAL
      NO.  FIG.      VERTICAL  HOT         INSTALLED   INSTALLED SPRING HORIZONTAL
NODE REQD  NO. SIZE MOVEMENT  LOAD          LOAD        LOAD      RATE   MOVEMENT


----+---+-----+----+--(mm.)--+-(N.  )+--(N.  )---+--(N.)-+-(N./mm.)+--(mm.)------

30   1 82       14   1.419     20772.  21170.      0.       280.     0.629
     PSS-GRINNELL                                 LOAD VARIATION =     2%

2505 2 82       17   6.070     37703.  41956.      0.       700.     0.129
     PSS-GRINNELL                                 LOAD VARIATION =    11%
```

5. RESULT

PIPELINE DESIGN

Throughput	= 16.68 MSCMD
Length of pipeline	= 10 Km
Supply Pressure	= 171.3913 psia
Supply Temperature	= 27^0C
Receiving Terminal Pressure	= 213.35 – 227.57 psia [Minimum Required]
Design Pressure	= 300 psia = MAOP
Fluid Name	= Propylene Gas
Molecular weight	= 42.10
Diameter	= 30 Inch
Thickness	= 0.511 Inch
Grade of Line Pipe	= XS
Hoop stress Sh	= 8806.26 psia
Longitudinal stress Sa	= 4403.13 psia
Erosional Velocity [ue]	= 99.667 ft/sec
Operating Velocity [u]	= 59.800 ft/sec
Operating Velocity [u]	= 59.9311 ft/sec – Calculated
Reynolds Number Re	= 26299987
Transmission factor $[1/f]^{0.5}$	= 20.74
Delivery Terminal Pressure	= 229.2361 psia – Calculated

COMPRESSOR DETAILS

Compressor Type	= Centrifugal Compressor [Single Stage]
Make	= Hitachi
Maximum Working Pressure	= 334 psia
Maximum Design Inlet Flow	= 696000 m^3/hr
Design Speed	= 4500 rpm
Compression Ratio	= 1.74
Adiabatic Efficiency [η_a]	= 0.7982
Overall efficiency [η_o]	= 0.7822
Power Required	= 15978.76 kW
Suction Pressure P_1	= 171.3913 psia
Suction Pressure P_2	= 298.2635 psia

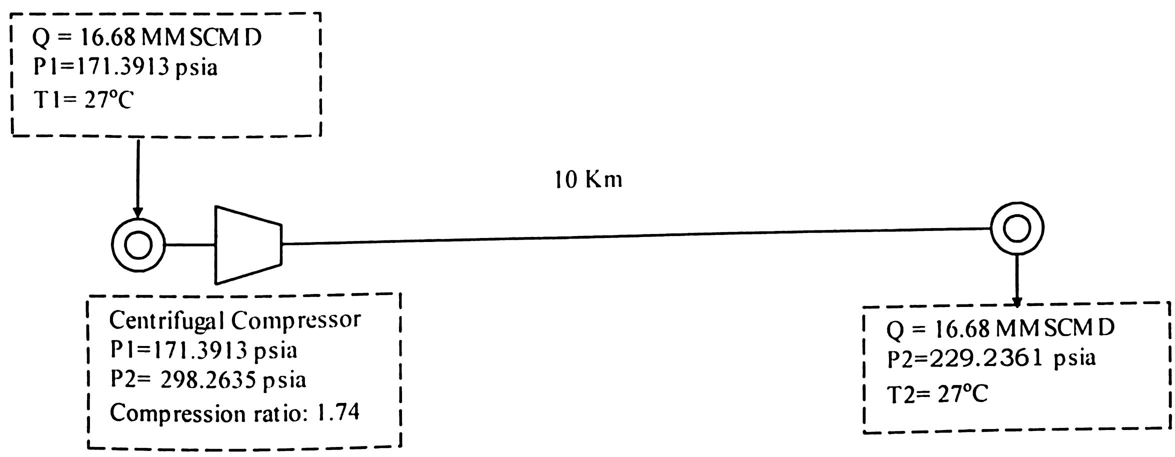

Figure 16 - Pipeline Design simulated Model

STRESS ANALYSIS RESULT

COMPRESSOR - SUCTION LINE

CASE 4 (SUS) W+P1

******CODE STRESS CHECK PASSED******

Highest Stresses: (kpa)

Code Stress %:45.7 @Node 250 Stress: 62962.3 Allowable: 137892.

Bending Stress: 35357.4 @Node 250

Torsional Stress: 1623.5 @Node 100

Axial Stress: 28432.3 @Node 199

Hoop Stress: 55949.9 @Node 29

3d Max Intensity: 63732.0 @Node 250

COMPRESSOR - DISCHARGE LINE

CASE 29 (OCC)

******CODE STRESS CHECK PASSED******

Highest Stresses: (kpa)

code Stress %:87.8 @node 1180

Stress: 161111.3 Allowable: 183396.

Bending Stress:130625.1 @Node 1180

Torsional Stress: 6113.8 @Node 1350

Axial Stress: 46012.0 @Node 1410

Hoop Stress: 93249.9 @Node 1410

3d Max Intensity: 187930.4 @Node 1180

6. CONCLUSION

For the transportation of 16.68 MSCMD propylene gas from the refinery complex to the nearby petrochemical units has been transported through 10 km pipeline is designed to be of 30 inch with the wall thickness of 0.511 inch.

In this project the Process department and the Piping department activities has been carried and their results has been furnished for the effective, efficient and safer transportation of propylene gas to meet the customer demands at proper time to increase the productivity.

7. REFERENCES

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