

GENERAL STANDARD
FOR
ANALYZERS

0. INTRODUCTION

This Standard has been prepared in four parts, as listed hereunder:

- Part 1** General-Engineering Standard
- Part 2** General-Construction Standard
- Part 3** General-Material Standard
- Part 4** On-Line Process Stream Analyzers Specifications

PART 1**GENERAL-ENGINEERING STANDARD**

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1. SCOPE

The practices and requirements specified herein are some important guidelines for engineering and design of process stream analyzers used in determining the physical or chemical characteristics of petroleum and petrochemical products applied in Iranian Oil Industries.

Analyzers for laboratory or temporary uses are not covered herein. The recommended practices discussed should not be considered as substitute for expert skill and field knowledge.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be agreed upon by the Company.

API (AMERICAN PETROLEUM INSTITUTE)

- | | |
|---------|---|
| RP-550 | "Manual on Installation of Refinery Instrument and Control System, Part II- Process Stream Analyzers", Sections 1 through 11 (1985) |
| RP-500A | "Classification of Areas for Electrical Installation in Petroleum Refineries" |

ANSI/ASTM (AMERICAN NATIONAL STANDARDS INSTITUTE / AMERICAN SOCIETY FOR TESTING AND MATERIALS)

- | | |
|--------|---|
| D 3764 | "Practice for Validation of Process Stream Analyzers" (Sec. 5.03) (1980) |
| D 1265 | "Practice for Sampling Liquefied Petroleum (LP) Gases" (Sec. 5.01) |
| D 4057 | "Practice for Manual Sampling of Petroleum and Petroleum Products" (Sec. 5.03) |
| D 4177 | "Method for Automatic Sampling of Petroleum and Petroleum Products" (Sec. 5.03) |
| F 307 | "Practice for Sampling Pressurized Gas for Gas Analysis" (Sec. 10.05) |

BSI (BRITISH STANDARDS INSTITUTION)

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|------------------|--|
| BS-476
Part 1 | "Fire Tests on Building Material and Structures" |
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ISA (INSTRUMENT SOCIETY OF AMERICA)

- | | |
|---------|--|
| S 7.3 | "Quality Standard for Instrument Air" |
| RP-12.6 | "Installation of Intrinsically Safe Instrument Systems in Class 1 Hazardous Locations" |
| S-12.4 | "Instrument Purging for Reduction of Hazardous Area Classification" |

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)

- | | |
|--|--|
| NFC-496 | "Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations" (1982) |
| Bulletin 70 / National Electric Code (NEC) | |

NACE (NATIONAL ASSOCIATION OF CORROSION ENGINEERS)

MR-01-75 "Sulfide Stress Cracking Resistant Metallic Material for Oil Field Equipment"

ANSI/ASTM (AMERICAN NATIONAL STANDARDS INSTITUTE / AMERICAN SOCIETY FOR TESTING AND MATERIALS)

B 31.3 "Chemical Plant and Petroleum Refinery Piping"

3. GENERAL CONSIDERATIONS

On-line process stream analyzers and their pertinent sampling systems are generally complex and expensive installations, therefore the installation of on-line analyzers may be limited to the applications when the measurement of properties will cause advantageous plant operation.

On-line process stream analyzer application will only be justified if they are used effectively in the following circumstances:

- a) to restrict product degradation in case of change of mode of the plant operation or when starting up;
- b) to control products as close as possible to the specifications in order to minimize the off-specification quality;
- c) to maintain high efficiency of boilers and furnaces;
- d) corrosion control;
- e) pollution control;
- f) personnel and plant safety.

To satisfy the above mentioned objectives, the following main requirements shall be considered in design and installation of on-line process stream analyzer:

- to meet all safety requirements;
- to make certain that accurate and reliable analysis is to be attained;
- to provide facilities for necessary testing, calibration, and isolation;
- to improve on-stream time of the analyzer by proper installation design and equipment selection.

For environmental conditions preparation, preventive maintenance, adjustments and fast repairs of analyzer equipment and the following economical considerations, centralized analyzer house shall be considered:

- combined instrument cable channels;
- common supply of power, water and steam;
- common drain and vent lines.

Centralization shall be realized by grouping the analyzers in the ventilated house, to form a safe area for maintenance while the analyzers are energized.

There are, however, exceptional cases where field mounting is acceptable, for instance for analyzers which are safely and easily serviceable on site, or transportable analyzers.

In some cases sampling conditions dictates no choice unless installation of analyzers in the field despite of all centralization advantages. In such circumstances, a suitable weather protection shelter shall be considered.

3.1 General Design Consideration

The following requirements shall be considered in design of analyzer system.

3.1.1 All process analytical instrument readings required by the operator shall be made available in the control room via display instruments.

3.1.2 The analyzer equipment, other than the manual stream selection switches and trend recorders shall be mounted on a single rack at the back of the main control board in the main control room (if applicable).

3.1.3 Electrical wiring of instruments shall conform to IPS-E-IN-190, "Transmission Systems".

3.1.4 The control circuits of the analyzer should be powered from a dedicated electrical control panel. Each analyzer shall have an overcurrent protective device (magnetic type circuit breaker or fuse). Local disconnect switches shall also be provided, so that the instruments can be safely serviced. Cabinet heaters, circulating pump motors and other devices which draw relatively high currents may be powered locally.

3.1.5 Signal wiring shall be run to the control room in separate conduit or cable. It shall be routed to the receiver instrument by the shortest most direct route which is feasible.

3.1.6 Process control loops which include an analyzer shall normally be cascaded. In some cases where the analyzer output is continuous and without delay, direct control may be provided.

3.1.7 Holding circuits shall be provided when the analyzer output is used for trend recording in addition to the signal used for control loop.

3.1.8 Current to pneumatic converters shall be considered, if necessary.

3.1.9 Repeater amplifiers with grounded input and floating output shall be considered for analyzers working in conjunction with an electronic controller.

3.2 Analyzer Location Selection

3.2.1 All analyzer components and equipment installed in process area exterior to the enclosure or analyzer house shall be located as close as practicable to the sample point and shall be provided with a roof cover to protect service personnel and equipment from thundershowers, process spills, falling objects, and sunlight.

In some applications, shielding against radiant heat exposed from surrounding equipment may be required.

3.2.2 The analyzer components shall be protected from the following substances:

- Hot apparatus,
- severe ambient temperature changes,
- electrical surge shock,
- vibration,
- mechanical shock damages.

3.2.3 The analysis cell location shall be selected in a manner to be conveniently accessible regardless of the fact that it is located at grade or some elevated point.

4. ANALYZER INSTALLATION IN HAZARDOUS LOCATION

4.1 Safety Considerations

4.1.1 The probability of atmosphere at analyzer location to contain flammable material with explosive or ignitable mixture limit and whether this condition exists normally or only as the result of abnormal conditions (i.e., equipment failure) shall be considered in safety design of analyzer installation.

4.1.2 The possibility to open the analyzer enclosures while the units are energized, which makes the condition as hazardous, shall be considered in safety design of analyzer installation.

4.1.3 The interior of the analyzer enclosure is a safe area when the ventilation system is operating, but when the ventilation fails, it will be potentially hazardous area. Therefore, all equipment shall satisfy the requirements for Division II areas, or the electricity supply shall be automatically switched off when the ventilation system fails.

4.1.4 Wall sockets in analyzer houses used for electricity supply to electric tools and test equipment must be switched off when the ventilation system fails.

4.2 Analyzer Purge Systems

Purging is the most commonly and accepted method for reduction of explosion hazards in the vicinity of a source of ignition. Depending on the area classification and the type of instrument, the following purge systems shall be applied.

4.2.1 Purge overpressure and low flow protection with electric interlock (System A)

The purging pressure provided in the enclosure of the analyzer shall be in the range of 5-25 mm-H₂O, which shall normally be determined by the length of a dip-tube in a water filled bubble glass. The resulting purge flow shall provide at least 5 times of the flow required to dilute any leaking flammable fluids below the LEL (Low Explosive Limit).

In compliance with the above requirements, the sample lines to the analyzer shall have engineered restrictions to limit the flow of escaping hazardous fluid in case of seal failure.

An electric interlock shall be provided by means of a high/low pressure switch. The high setting shall energize an alarm for operators attention. The low setting shall de-energize the power supply to the analyzer (see Appendix A1).

4.2.2 Purge system with low-pressure protection, electric interlock (System B)

Details of purging is similar to those mentioned in 4.2.4 hereunder. An electric interlock shall be provided by means of a two setting low pressure switch. One setting shall be used for electric disconnection of the analyzer and the other one for alarm activation (see also Appendix A1).

4.2.3 Purge system with low-pressure alarm (System C)

Details of purging is similar to those mentioned in 4.2.4 hereunder. A low pressure alarm only shall be provided additionally for this System (Appendix A1).

4.2.4 Purge system only (System D)

The Purging in the casing of the analyzer shall be considered in the range of 5-25 mm-H₂O, which shall normally be determined by the length of a dip-tube in a water filled bubble glass. The purge flow resulting by the above mentioned over-pressure shall ensure at least 10 Volume changes of the casing per hour. A restriction orifice shall be installed in the supply line of the purge medium, (refer to Appendix A1).

4.3 Requirements on Instrument Enclosures

Process stream analyzers consist of different equipment installed in various locations in the refinery. These locations are differently classified according to hazardous area classifications. For area classifications, the recommendations and standards issued by NFPA and API shall be followed. The process stream analyzer equipment casing shall be specified to meet the following requirements.

4.3.1 Instruments in Class 1, Division I areas

Installing electrical instruments in Class 1 Group A to D, Division I areas shall be avoided. Where such an installation is absolutely unavoidable, then all instrumentation shall be either.

- intrinsically safe, or;
- purged system (see Notes 1 and 2 hereunder).

Notes:

1) For non-flame-proof casing containing flammable material:

- System A shall be used when air is the purge medium.**
- System B shall be used when an inert gas is the purge medium.**

2) For casings not containing flammable material and for flame-proof casings containing flammable material, system B shall be considered.

4.3.2 Instruments in Class 1, Division II areas

Instrumentations specified for installation in this area shall be either:

- intrinsically safe;
- flame-proof;
- purged system (see Notes 1 and 2 hereunder).

Gas classification group of the materials shall be considered as group A to D.

Notes:

1) For casing containing flammable material and ignition capable components, one of the following systems shall be used:

- System A when the purge medium is air (see Appendix A1, page 2).**
- System B when the purge medium is an inert gas (see Appendix A1, page 2).**

2) For casings containing no flammable materials but containing ignition capable components:

- System B shall be employed.**

4.3.3 Instruments in safe areas

Analyzers for flammable materials generally create a Division II in surrounding area, even where the area is otherwise safe. In closed shelters, the hazardous area classification shall be considered as Division I for analyzer installations. Purging system shall be designed, in such cases, to reduce the classified hazards.

Purging for analyzers on non-flammable process streams may be considered for improved protection against ambient conditions. System D in this application is sufficient.

4.3.4 Instruments in analyzer houses

All instruments in analyzer house shall be suitable for Class 1, Group A to D, Division II areas.

All purged instruments shall have a low pressure alarm switch in the common purge supply line.

In analyzer house, purging system for the house shall be provided similar to System A. In system A application for analyzers, a high and low pressure switch shall be installed between the two restriction orifices for each instrument. Typical details of such design is presented in Appendix A1.

4.4 Purge Medium Supply and Disposal

Normal purge medium shall be preferably considered as instrument air.

Inert gas (normally nitrogen) shall be considered when Low Explosion

Limit (LEL) is difficult to be obtained by air.

Disposal of purging gas out of casings (which contains flammable material) shall be made by means of open vent lines conducting the gas outside the analyzer house and away from places where could affect the area classification for other equipment.

4.5 Calculation of Flow Restriction Orifices

Calculation of restriction orifices shall be based on nomogram presented in Appendix A1, (page 4 of 4).

Example of application for this nomogram is presented in the same Appendix. (page 3 of 4).

4.6 Purge Alarms

Failure alarm of the purge system shall be detected by a low pressure switch installed on the supply line to the analyzer and shall be indicated by visible and audible alarm in the control room for both field mounted and analyzer house mounted analyzers. The alarm shall also be indicated in analyzer house.

4.7 Electric Interlock Requirements

Purge failure shall be detected by a pressure switch (with low setting for System B and high/low settings for System A) and shall be interlocked with the power switch via relay circuits. Switch-off action shall be without delay, switching back to on-state shall be activated after at least five volume changes have taken place in the analyzer casing. Suitable alarms shall be considered, in the interlock circuit, to indicate the power supply situation of the analyzer circuit.

If automatic switch-on may damage the instruments, then a manual restart switch shall be considered in the power supply line. The above requirements are schematically indicated on Appendix A1.

5. ANALYZER HOUSE REQUIREMENTS

5.1 General

Analyzer house shall be totally closed premise, provided with a full redundant forced ventilation system. Air intake for the analyzer HVAC shall be taken from the safe area. The analyzer house may be either prefabricated or masonry type according to the size and project requirements.

Analyzer house shall be located on the process area according to the take-off point location of analyzers as specified in article 5.3 (location of analyzer houses).

An air conditioning system shall be provided for analyzer rooms in order to maintain the ambient temperature within the limits specified by the analyzer vendors.

5.2 Safety Consideration

Generally all analyzers and equipment located in analyzer house shall be suitable for at least Class 1, Division II areas according to API RP-500A and pertinent NFPA codes, to be able to continue their operation under ventilation failure condition.

The following measures shall be considered in the design of the system to minimize the hazardous condition in the analyzer house.

- 5.2.1 Quantity of flammable materials leakage retained in the analyzer house shall be kept to a minimum.
- 5.2.2 Efficient ventilation system shall be provided for the analyzer house to dilute any leak of flammable gases or vapors, to reduce the concentration of air/flammable gas vapors below the Lower Explosion Limit (LEL).
- 5.2.3 All other precautions shall be considered, to make the area safe under ventilation failure condition.
- 5.2.4 Provision for safe disposal of samples shall be arranged.
- 5.2.5 Analyzer houses shall be provided with fire protection facilities.

5.3 Location of Analyzer House

The analyzer house location shall be selected in a manner to be in a non-hazardous area or in Class 1, Division II area in which a non-hazardous safe area can be found in the immediate vicinity of the area for the ventilation air inlet. It shall be noted that the sample lines and the sample conditioning system will most likely create a Division II area around the analyzer house anyhow.

The following criteria shall be considered in selecting the location of the analyzer houses:

- 5.3.1 The analyzer houses location shall have optimum minimized distance from the sample points of the pertinent analyzers, in a manner, to minimize the sample transport time lag and cooling of the sample due to the lower ambient temperatures.
- 5.3.2 The location shall be free from water and process liquids spillage.
- 5.3.3 The location shall be free from shock and vibrations caused by railroads, main roads traffic and process equipment such as compressors, etc.
- 5.3.4 The location shall allow free personnel evacuation in case of emergency.
- 5.3.5 The location shall allow free transport access of all analyzer house installed equipment and consumables, such as; analyzers, gas cylinders, tools and test equipment.

5.4 Dimensions of Analyzer House

The sizing of the analyzer house shall provide enough room for all instruments to be easily accessible on all sides for adjustments, connecting and repair activities.

Sufficient space shall be provided for a sink, work bench, terminal boxes for electrical and signal cables and all auxiliary equipment, such as; recorders, control units, signal converters, etc.

The size of the analyzer house shall preferably be determined after making the detailed layout drawing for the best arrangement of all equipment to be installed in the analyzer house according to vendors' recommendations.

The following criteria shall be considered in sizing the dimensions of the analyzer houses.

- 5.4.1 The internal width of the house shall be selected with suitable size to allow the individual installation of analyzers against opposite walls.
- 5.4.2 The internal height from ceiling to floor shall not be considered less than 2.80 meters.
- 5.4.3 The length shall be sized in a manner to accommodate the required number of installed analyzers and all other requirements stated hereafter, plus 50% spare space.
- 5.4.4 For preliminary estimation purpose, the average length shall be considered as 900 mm for usual analyzers and 1800 mm for large instruments such as; process gas chromatographs, viscometers and vapor pressure analyzers.

5.4.5 Attention shall be paid to the space required on the outside walls. Space shall be reserved for the installation of sample conditioning system on outside walls of the analyzer houses, in a manner, to situate the analyzers and their pertinent sample conditioning systems back to back located.

5.4.6 The sample conditioning space shall have a weather protection cover in a manner that the natural ventilation in the sample conditioning area is conserved.

5.4.7 Junction boxes for signal cables should be located on outside wall against that part of the wall which sink, work bench, etc. are located opposite to sample conditioning installed wall.

5.5 Installation Design Considerations

5.5.1 Installation of analyzers

Analyzers may be either wall, rack mounted or free standing type to be installed along the two longest walls. The following requirements shall be considered in installation engineering of the analyzers layout, as a minimum (See Appendix A3).

5.5.1.1 The sample conditioning equipment shall not be installed inside the building unless proper operation of the system obliges the inside installation.

5.5.1.2 Accessories like, fast loop system, sample recovery system, calibration and carrier gas bottles shall be installed on the external wall of the analyzer house.

5.5.1.3 The sample conditioning equipment shall be connected to the analyzer by either a single ¼" outer diameter stainless steel tube or by means of a secondary fast loop. (½" OD)

5.6 Construction of Building

The following requirements shall be fulfilled in construction of analyzer houses.

5.6.1 The type of construction materials selected for construction of the analyzer house shall; neither cause operational difficulties nor create safety hazards.

5.6.2 The walls of the analyzer house shall be strong enough to take the load of wall mounted analyzers and pertinent sampling system.

5.6.3 For the finish of floor, roof and walls, reference shall be made to pertinent Civil Engineering Standard (IPS-G-CE-230 "Buildings and Construction Methods").

5.6.4 The building shall be provided with two opposite doors. The doors shall be tight fitting, outward opening, self-closing type. The doors shall be sized for safety and fire and also for passage of the largest equipment to be installed in the house.

5.6.5 The interior of the building shall be readily visible, through the armored glass windows of the doors, from the outside of the analyzer house.

5.6.6 It shall be possible to open the doors from inside by means of a simple door handle or push bar only for escape purpose in an emergency and there shall be one standard key to lock or open the doors of all analyzer houses in the plant from outside.

5.6.7 Housings shall have a minimum unobstructed headroom of 2 meter and the location of the door shall be suitable for prevailing weather conditions.

5.6.8 The window shall be of flame retardant wired material as defined in BS-476 Part 1.

5.6.9 Analyzer house shall be equipped with suitable gas and fire detection and alarming system.

5.7 Artificial Ventilation System

5.7.1 General requirement

The analyzer house shall be ventilated with air to keep out flammable and toxic gases, and any leakage of flammable gases and/or vapors which may occur inside the house shall be diluted to a safe level.

The flow of air shall be sufficient to:

- Dilute escaping vapors, resulting from the rupture or failure of any sample or service line, to less than 20% of the Low Explosive Limit (LEL) around any potential means of ignition.
- Maintain the pressure inside the analyzer house at 0.25 m bar above that of the outside atmosphere, to prevent entry of hazardous atmosphere.

However, at least 10 volume changes per hour shall be provided to ensure adequate mixing of the internal atmosphere, or at least 20m³ of air per installed analyzer per hour, whichever is the greater, to dilute any normally escaping flammable gas or vapor to a non-hazardous level.

The air flow shall be sufficiently turbulent to avoid dead corners which accumulation of hazardous gases may occur.

The required air flow rate shall be calculated for each analyzer house, based on the above conditions, and submitted to the Company for approval.

5.7.2 Air intake system

The air intake shall be through a stack provided with a rain-hood. The design of the intake duct and the diameter of the stack shall be sized in a manner to limit the air velocity inside the ducting to 8 m/second, maximally.

5.7.2.1 Air inlet and outlet openings

- The ventilation air shall enter and escape from the analyzer house via ducts and openings. Ventilation air shall be drawn from a safe area(non-hazardous).
- The direction of the flow of air within the house shall ensure an air movement through and around all equipment installed inside the house irrespective of the wind direction and strength.
- The inlet of the air ducting shall be located at a safe distance away from any Division II area.
- Outlet openings shall be at floor and ceiling levels to allow escape of gases and vapors both heavier and lighter than air.
- The outlets shall be flush with floor and ceiling to prevent accumulation and trapping of gases and vapors.

5.7.2.2 Ducting

- Air shall enter and leave the analyzer house via ducting.
- The ducting material shall be of non-corrosive such as; hot-dipped galvanized steel.
- Ducts shall not run through Division I nor II areas. Inlet ducts shall be air-tight and shall be leak tight when passing through Division II areas.
- Filter shall be installed in the ducting to be easily accessible for cleaning or replacement.
- Atmospheric opening of the ducting shall be protected from rain and particulated matters irrespective of the direction and velocity of the wind with no effect on the ventilation.

5.7.3 Fan requirement

5.7.3.1 Ventilation shall be by a centrifugal or axial fan driven by a directly coupled motor installed either inside or outside the building with suitable protection.

5.7.3.2 If the motor installed inside the ducting, it shall be suitable for Division I areas, otherwise it shall be suitable for Division II areas.

5.7.3.3 The blades of the ventilator fan shall be of non-sparking material.

5.7.3.4 The power supply to the fan motor shall be independent of all analyzer house safety trip circuits.

5.7.3.5 Dual ventilation system shall be installed in houses containing analyzers which form part of a process control system.

5.7.3.6 The fan support and frame construction shall be of adequate rigidity to prevent resonance and vibration.

5.7.4 Climatic condition

5.7.4.1 The temperature inside the analyzer house shall never be less than 15°C.

5.7.4.2 The maximum temperature inside the analyzer house shall be 35°C with maximum humidity of 75% unless the analyzers or equipment used dictates lesser maximum temperature and humidity.

5.8 Utilities and Facilities

5.8.1 Electric power supply

5.8.1.1 The Electric supply shall be provided with suitable switch board panel to de-energize analyzers and pertaining electrical equipment per analyzer and analyzer installation, by dedicated switches.

5.8.1.2 Socket outlets for electric tools or test equipment shall be provided with different switches from other circuits in the analyzer house. These sockets shall be interlocked on the ventilation system, as specified hereunder (5.8.1.8).

5.8.1.3 The power supply distribution board shall be outside the building in the vicinity of the analyzer house door, unless otherwise specified.

5.8.1.4 The power supply to analyzers shall be 110 V ac/50 Hz or 24 V dc, as specified.

5.8.1.5 All electrical equipment shall suit the area classification encountered.

5.8.1.6 Trunking shall be provided for the electric power supply cables to the instruments in analyzer house. This trunking shall be separate from the trunking for signal cables.

5.8.1.7 Electrical power cables and instrument signal cables shall enter and leave the analyzer house via separate openings in the floor, at one of the corners in the analyzer house.

5.8.1.8 Test equipment, electrical tools and electrical equipment without adequate protection for Division II area shall be connected to the electricity supply via wall sockets only; the supply for which shall be automatically isolated upon ventilation failure.

5.8.2 Air, water and steam

5.8.2.1 The common air supply shall be provided with a block valve, and a filter/regulator station.

5.8.2.2 PVC coated copper or SS 316 tubing, as specified, shall be used downstream of the air filter.

5.8.2.3 The common cooling water line shall be provided with a block valve, filter and reducing station. Individual users of cooling water shall be provided with a variable area flow-meter and needle valve to adjust the flow.

5.8.2.4 Sweet water shall be used for cooling, preferably.

5.8.2.5 Used cooling water may be piped to the waste sample drain header.

5.8.2.6 Where steam is required for analyzers, the common steam supply line must be provided with a block valve, condensate drain, and a strainer. After the strainer, copper tubing or stainless steel tubing shall be used.

5.8.3 Vent and drain piping systems

5.8.3.1 Vent and drain systems shall be installed in the conditioning area against the outside wall(s), of the analyzing part of the house, and shall be adequately supported at intervals of 1 meter, maximally.

5.8.3.2 The minimum size of the piping for vent header shall be 2" (DN50) and 3" (DN80) for liquid drain header. The interconnecting piping shall be minimum ½" (DN15).

5.8.3.3 Connection to drain headers without isolating valve shall be provided with a goose-neck liquid seal. A funnel and goose-neck liquid seal may be installed, where required.

5.8.3.4 Special attention shall be given to ensure the segregation of water and oil drain headers. Cooling water shall not be discharged into condensate return systems.

5.8.4 Additional utilities

5.8.4.1 The following additional utilities shall be provided, when specified by the Company:

- tool air;
- nitrogen;
- hydrogen gas (as a carrying gas);
- LP steam;
- MP steam (15 bar);
- condensate supply and return lines;
- sample recovery system (e.g. effluents with lead content).

5.8.4.2 All utilities shall have main shut-off valves, grouped together in the vicinity (not less than 2 meters) outside the analyzer house. The shut-off valves shall be clearly identified by means of yellow label.

5.8.5 Telephone

A telephone installation shall be provided inside each analyzer house. The telephones shall have type of protection Ex'd' or Ex'ib' for use in Division II areas.

5.8.6 Lighting

Adequate artificial lighting shall be provided inside and outside the analyzer house, as required for carrying out the maintenance and adjustments on complicated equipment. Execution of the lighting fixtures and equipment shall be suitable for the area classification.

5.8.7 Automatic fire fighting system

Automatic fire fighting system shall be provided, if specified in the project requirements.

5.9 Safeguarding System Through Ventilation

5.9.1 The ventilation air flow shall be measured in the suction duct by means of a venturi-tube or equivalent flow measuring devices to check the differential pressure to be approximately 0.25 m bar under the normal operating conditions (refer to NFPA-496, 3.3).

Venturi-tube shall be equipped with flow transmitter with a pneumatic switch in the output of the transmitter. The switch action shall provide the following interlock and annunciation functions:

- Audible and visible alarm in the analyzer house and in the remote control room.
- Switch-off all electricity supplies to the equipment not suitable for Division II areas.

5.9.2 Doors shall be provided with "Close" position switches connected to an audible alarm in the analyzer house to be silenced by closing the door only. The doors shall be provided with automatic closing mechanism.

6. FIELD MOUNTING OF ANALYZERS

6.1 General

Field mounting of analyzers may only be considered in the following conditions:

- the cost of analyzer house is unfeasible in comparison to anticipated advantages;
- the distance of selected location of the analyzer house would result an unacceptable time lag in sample transportation;
- the sample is non-flammable and the mounting of the analyzer can be located in a safe area.

When the field mounting has to be performed in a dangerous area, intrinsically safe circuits for the analyzer shall be considered.

6.2 Weather Protection

6.2.1 The analyzer system shall be designed, so that; there is no dangerous emission of flammable or toxic vapors. No liquid likely to emit such vapors shall be discharged or filled in sample containers, inside an analyzer housing.

6.2.2 When an analyzer is located in a hazardous area, the preferred installation is a cabinet or shelter substantially open and free from any obstruction to the free and natural passage of air. In this case, the area classification of the shelter/cabinet will be the same as surrounding area.

6.2.3 Field mounted analyzers shall be provided with adequate protection against adverse climatic conditions, such as; rain, sun radiation, process fluids and water spills. Shielding against radiant heat from surrounding equipment (such as furnaces) shall be provided, if necessary.

6.2.4 The analyzers may be mounted individually or in groups in analyzer cabinets or shelters.

6.2.5 In case of free ventilation obstruction, then the area classification of the interior shall be considered as Division I and execution of the analyzers and all pertinent electrical equipment shall be selected accordingly, using one of the following technologies as may be applicable:

- intrinsically safe;
- flame-proof;
- purged.

6.2.6 Suitable heating shall be provided to protect the analyzer and associated sample handling equipment, where necessary, considering that even analyzers with internal thermostatically controlled heating may require heating to protect them against external temperature according to the climatic conditions.

7. SAMPLE HANDLING

7.1 Sample Take-Off and Transportation

7.1.1 General

Sample handling systems shall be extracted such that the sample conveyed to the analyzer represents the property of the process material at best suited pressure, temperature, flow rate for the proper operation of the analyzer.

Basically each sample handling system consists of the following four elements:

- a) sample take-off tap;
- b) sample transport system to the analyzer;
- c) sample conditioning system;
- d) sample return and/or sample disposal system.

Except for some analytical instruments which are designed for direct immersion of the measuring cell into the process pipe.

The design of sampling system shall be in a manner to have target time lag of 1 minute totally, but in no circumstances this time lag shall be more than 5 minutes.

7.1.2 Sample take-off tapping

7.1.2.1 Sample tapplings for gaseous samples shall be taken from the top of the main line and for liquid samples from the side of process line.

7.1.2.2 For liquid samples, the take-off arrangement shall enable unplugging and flushing of the sample lines.

7.1.2.3 The location of the sample take-off tap shall be conveniently accessible for maintenance and inspection.

7.1.2.4 Sampling system shall be protected against plugging by means of wire mesh strainer or filters provided in the line to the analyzer.

7.1.3 Sample transportation

7.1.3.1 Normally, (for gas samples) or (for liquid samples) stainless steel tubing shall be used for sample transportation unless other materials may be required because of sample compositions and conditions.

7.1.3.2 Sample by-pass around the analyzers shall be provided to ensure that; the sample lines are purged and to reduce the time lag of sampling. The sample by-pass shall be vented to atmosphere or back to a lower pressure part of the process for gases and shall be drained to a sewer or a lower pressure part of the process for liquids.

7.1.3.3 Heat tracing or insulation of the sample line is required if condensation of the sample can occur at ambient conditions.

7.1.3.4 Sample may be transported to the analyzer by one of the following methods:

1) Single line to the analyzer using a by-pass stream

- This system shall consist of a single line with a by-pass stream branched off close to the analyzer to maintain high sample transport velocity; resulting small transportation time lag.
- This system shall be used where no return point for a fast loop is available.

- In case that liquid samples may be vaporized, the liquid shall be pressure reduced and completely evaporated adjacent to the process sample take-off tap in order to reduce the by-pass stream quantity.
- The by-pass stream shall be piped to drain or vent. A sample recovery system shall be installed where economic justification permits.
- Block valves shall be provided for the system to allow maintenance of sample conditioning system.

2) Fast loop system

- Fast loops shall be selected for sample transportation as the preferred solution, since; there is no waste of product, the time lags are small and the piping can be arranged of reasonable size with simpler installation.
- Fast loops shall be a circulating loop built over one of the following plant elements which creates differential pressure (refer to Appendix A4):
 - a) Pumps with relatively constant differential pressure.
 - b) Control valves which produce variable differential pressure. The fast loop size shall be calculated for the differential pressure existing when the design flow is passing through the control valve, in a manner that; when the control valve is fully closed, the fast loop does not pass more than 10% of the design flow of the process pipe.
 - c) Process equipment which produce differential pressure depending on the particular equipment.
 - d) Restriction orifices with normally low relative differential pressure.
 - e) Impact tubes which usually produce low differential pressure. Application shall be limited to situations where no restrictions in the process line are allowable.
- The return points of the fast loops for the analysis of gases which are sampled from the liquid phase shall be chosen such that; the pressure at these points is always at least 2 barg higher than the vapor pressure of the sample to prevent flushing of the product in the fast loops.
- Minimum number of joints shall be used, to minimize possible leakages and to maintain the fast loop flow as high as possible for a given differential pressure. In performing this requirement, welding fittings shall be considered rather than screwed fittings.
- Installation of a fast loop pump shall be considered when no suitable differential pressure producing equipment can be found in the plant stream. In such a case, the pump shall be installed close to the take-off tap and the suction piping shall be designed one size larger than the discharge piping.
- The fast loop pump performance shall be selected to guarantee a sample velocity of approximately 2 m/sec in the loop supply line to the analyzer, in a manner that; pump capacity does not exceed 10% of the design flow for the pertinent process line.
- The fast loop shall be provided with block valve on fluids which may easily solidify during standstill situations, a bypass valve shall be also considered to by-pass the sample conditioning system when the system is out of operation.

7.2 Sample Conditioning

7.2.1 General

- #### 7.2.1.1
- Process stream samples normally require conditioning to make them suitable for the analyzer.

7.2.1.2 The requirements set-forward by the analyzer vendor shall be carefully compared with the process sample conditions to fulfill the operation requirements.

7.2.1.3 The general requirements for conditioning specified herein shall be considered as well as the analyzer vendor requirements.

7.2.2 Removal of entrainments in liquids

7.2.2.1 Liquid entrainments, such as; water in oil or oil in water, shall be coalesced and further separated by means of gravity difference methods.

7.2.2.2 Entrained gases may be separated in a similar way.

7.2.2.3 In order to prevent fouling of the coalescer packing, solids shall be removed by filtration before the coalescer.

7.2.2.4 The entrainments separated may be disposed in the return line of the fast loop system. For single line systems an automatic drain or gas vent shall be considered.

7.2.3 Removal of entrainments in gas

7.2.3.1 Liquid or solid entrainments in the gas sample stream shall be minimized by proper selection of sample tap location.

7.2.3.2 Separation may be obtained in the sampling system by one of the following methods, as applicable:

- a) Cyclone separator may be used when the sample has adequate velocity;
- b) by coalescing the liquid droplets and then separating by means of gravity difference method;
- c) filtration for solid entrainments.

7.2.3.3 The liquid removed of gas may be disposed in the return line of the fast loop system or in an automatic drain-pot in case of a single-line system.

7.2.4 Chemical treatment and drying

7.2.4.1 When sample streams contain corrosive gases damaging the analyzer, these shall be removed by passing the sample through a liquid or a packed bed of solid chemicals.

7.2.4.2 When the sample contains moisture influencing the accuracy of the analyzer, this moisture shall be removed by means of chilling and trapping method. Normally desiccants shall be avoided, since, they are spent and not functioning or they may adsorb constituents other than water.

7.2.4.3 Where a liquid treating agent is applied, gas streams must be broken up in small bubbles to ensure a large liquid to gas contact area.

7.2.4.4 In order to maintain a representative sample, the treating agent used shall not influence the property to be measured.

7.2.4.5 The volume of treating equipment shall be as small as possible to keep response times low. On the other hand the volume of treating or drying agent shall be large enough to remain effective for at least one week enabling the changing of chemicals to be performed on a routine basis.

7.2.4.6 The common method of removing acid gases are application of caustic soda solution or caustic pellets. Where this treatment does not meet the requirements, then other technical solutions may be considered.

7.2.5 Cooling and heating

7.2.5.1 Some liquid samples may require cooling before entering the analyzers, some of which will be indicated herein:

- a) samples for Initial Boiling Point (IBP) analyzers have to be cooled below their IBP;
- b) samples for Flash Point (FP) determination have to be cooled well below their FP;
- c) analysis of steam samples which are only possible when they are condensed;
- d) samples which require cooling to obtain separation between condensable and non-condensable vapors, i.e. flue gases sucked by a steam jet.

For the above mentioned samples, cooling system shall be provided.

7.2.5.2 For the samples which their temperature exceeds the temperature compensation range of the analyzer or where the temperature of the sample exceeds the capabilities of thermostated heat exchangers in the analyzer, cooling system shall be provided. Cooling medium for analyzers shall be sweet water preferably.

7.2.5.3 Cooling by means of cold air from a vortex tube or by a mechanical refrigerant cooler shall be considered where sweet cooling water is too expensive or its temperature is not low enough.

7.2.5.4 Cooling medium for samples which may solidify at temperatures lower than 100°C shall be considered as hot condensate water. (i.e. long and short residue streams). The temperature of the condensate can be controlled by controlling the pressure of the steam in the steam condenser.

7.2.5.5 In order to prevent condensation of gaseous samples or to lower viscosity of liquid samples, heating shall be applied to the sample by means of either; steam, hot water or electrical tracing of the sample conditioning lines.

7.2.5.6 Necessary care shall be taken that the conditioned temperatures are maintained up to the analyzer.

7.2.6 System for vaporization of liquid samples

7.2.6.1 Vaporizer reducer shall be provided for samples which need vaporization before they can be handled by the analyzer.

7.2.6.2 Where the flow rate is not sufficient to prevent fractionation of the samples due to the limited turbulence in the comparatively large volumes, then installation of a capillary tube or a tube filled with an inert packing material such as sand or fire brick shall be considered on the inlet side of the vaporizer reducer.

7.2.7 Valving

7.2.7.1 Valves, considered for the system, shall have no "dead space" which will hold part of the sample material which later may mix with fresh sample and result erroneous results in the analysis.

7.2.7.2 Valves used for blocking purposes shall give a tight shutoff (i.e., ball or cock valve with resilient seating), especially where they are installed for stream switching.

7.2.8 Sample handling for analyzers requiring constant sample flow

Analyzers requiring constant sample flow shall be considered with one of the following three systems:

- a) a restriction valve with a rotameter;
- b) a constant flow unit;
- c) a sample dosing pump.

7.3 Sample Disposal System

7.3.1 General

7.3.1.1 Waste samples from analyzers or sample by-passes shall be returned to the process where the analyzers can operate at process line pressure, considering economical justification.

7.3.1.2 A safe disposal of sample through drains and vents shall be provided for waste samples which cannot be returned to the process stream.

7.3.1.3 Where the waste sample is of significant value, a sample recovery vessel and pump-out facility shall be considered for the system.

7.3.1.4 Where the waste sample may cause serious troubles if piped to drain (such as waxy products), or when no contaminated drain system is available in the near vicinity, then the recovered sample may be discharged in the plant feed line for reprocessing.

7.3.1.5 Open discharge inside analyzer houses shall be avoided especially with fluids having low flash points.

7.3.2 Vents

7.3.2.1 Venting of waste sample shall take place at a safe height, at least 4 meters above ground level and at least 1 meter above analyzer house roof level; where the analyzer house is located in an isolated open area; or at a safe height of 3 meters above the highest walk-way of the structure if the house is built under or close to a plant structure.

7.3.2.2 A Sphere with a radius of 1.5 meters around the vent line outlet shall be considered as a Division I area while a cylinder with a radius of 1.5 meters and a height of 4 meters under and 3 meters above the outlet shall be considered as Division II area, (see Appendix A2).

7.3.2.3 The vent outlet shall be located at least 1.5 meters away from any opening, i.e. doors, windows or ventilation vent holes of the analyzer house.

7.3.2.4 Special care shall be taken for venting of toxic gases in dangerous concentration.

7.3.2.5 Vent outlet shall be suitably shielded to prevent the backpressure produced by wind direction.

7.3.2.6 The vent outlet shall not be located in the air flow produced by the air cooled heat exchangers.

7.3.2.7 Provisions shall be considered to prevent liquid pockets to be formed in the vent line, if condensation of vapors can be expected. Such condensate may be automatically drained into the drain system via a goose-neck performing as a liquid seal.

7.3.2.8 Some analyzers which are very sensitive to back-pressure influences may have an open discharge to the atmosphere by written approval of the Company.

7.3.3 Drains

7.3.3.1 A Common drain line of 2 inch size shall be provided along each of the two longest walls outside the analyzer house to discharge each individual analyzer drains into them.

7.3.3.2 The drain line shall be atmospheric and must have an atmospheric vent line at the high end, with the lower end connected to the contaminated drain system via a liquid seal.

7.3.3.3 Tundishes shall be connected to drain line via a goose-neck liquid seal. A continuous water flow to this goose-neck shall be considered to maintain the seal when there is a possibility of continuous vent of low flash point material from the tundish.

7.3.3.4 When it is likely that drained material will solidify in the drain system due to low temperatures (as may be the case with waxy products) a steam heated tube has to be installed inside the drain line. (See Appendix A7 for typical details).

7.3.4 Gas disposal to flare

7.3.4.1 Hydrocarbon gases or vapors which cannot be returned to the process shall be discharged to a flare system.

7.3.4.2 The effluent gas pressure shall be kept constant by means of a back-pressure regulator.

7.3.5 Liquid disposal to recovery system

7.3.5.1 Hydrocarbon liquids, which cannot be returned to the process, shall be discharged into one of the following systems:

- plant hydrocarbon recovery system, or;
- drain pit for hydrocarbon products.

7.3.5.2 It shall be ensured that the total quantity of liquids disposed is limited to the minimum necessary.

7.3.6 Liquid disposal to effluent system

7.3.6.1 Aqueous fluids from analyzers using reagents shall be discharged into a dedicated effluent system used for contaminated effluents.

8. OBLIGATIONS AND SELECTION CRITERIA FOR ANALYZERS

8.1.1 Suitable detectors shall be considered for alarm and necessary safety precautions where toxic gases are processed or handled which may cause intoxication dangers to personnel who have to work in these areas.

8.1.2 Reference shall be made to the plant specification for data relating to analyzers, including:

- a)** specification of physical and chemical conditions of sample streams,
- b)** system requirements of; accuracy, reliability and servicing frequency,
- c)** display and output signal level information.

8.1.3 Single stream analyzers shall be used except in cases where the Company have specified multi-stream instruments.

8.1.4 The measurement dead time for analyzers such as chromatograph is equal to 1.5 times of the sampling time. Therefore chromatographs can have sample times of 3 to 30 minutes, which makes them unsuitable for self regulating loops unless the process time constant is exceptionally large (i.e., distillation column bottom product).

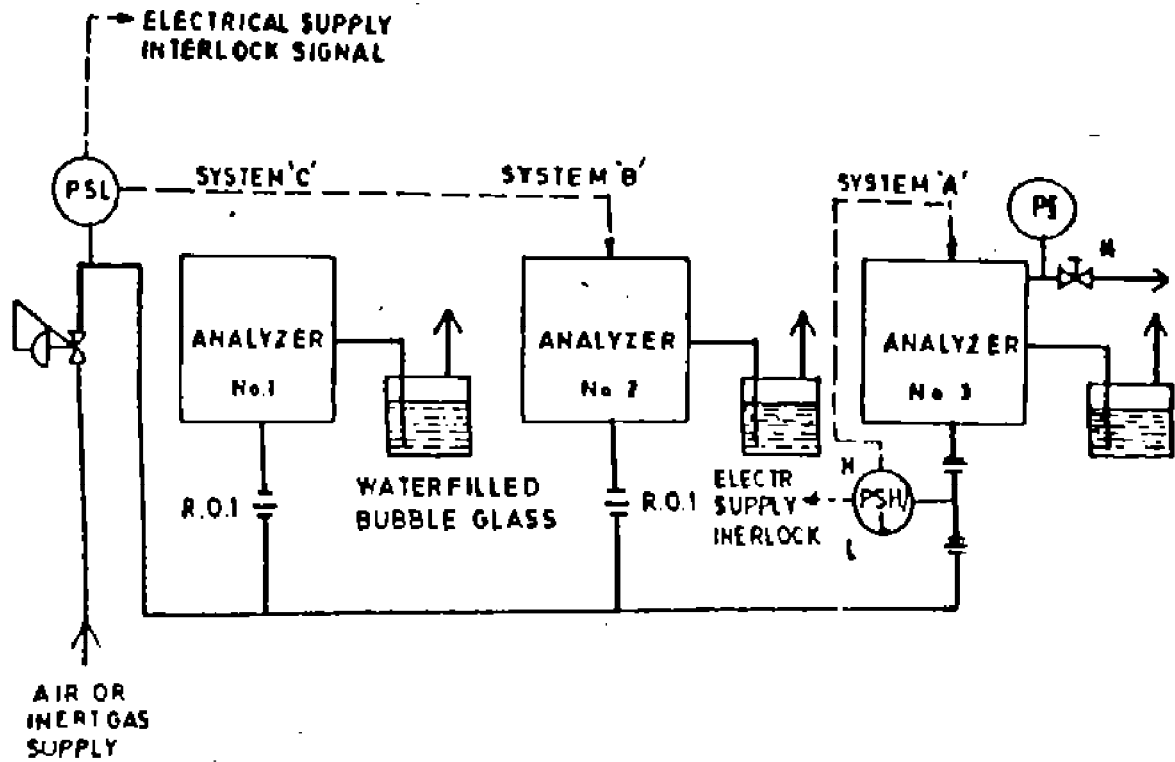
8.1.5 The mass spectrometer can provide an analysis in 10 to 40 seconds and should be considered for control when the performance of the loop is important and critical.

APPENDICES**APPENDIX A
INDEX OF DIAGRAMS**

A1	Purging system for instruments installed in analyzer houses	4 sheets
A2	Area Classification around analyzer house	1 sheet
A3	Typical arrangement of equipment in analyzer house	2 sheets
A4	Sample transport systems	1 sheet
A5	Typical analyzer sampling probe for line sizes 2" and above	1 sheet
A6	Typical vent line construction	1 sheet
A7	Analyzer house vent and drain system	1 sheet

APPENDIX A1
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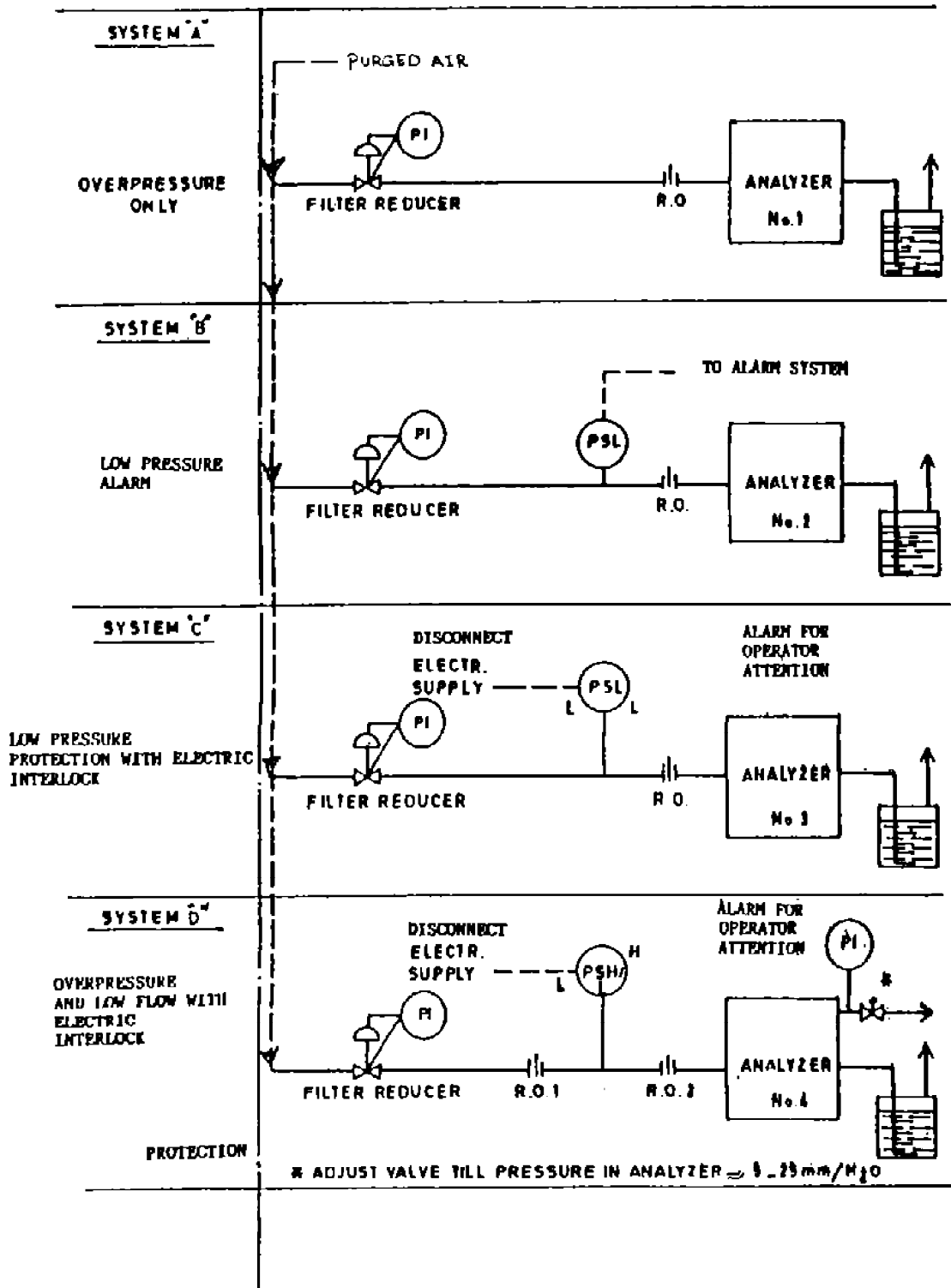
PURGING SYSTEM FOR INSTRUMENTS INSTALLED IN ANALYZER HOUSE



* Adjust valve till pressure in analyzer $\approx 5-25$ mm/H₂O.

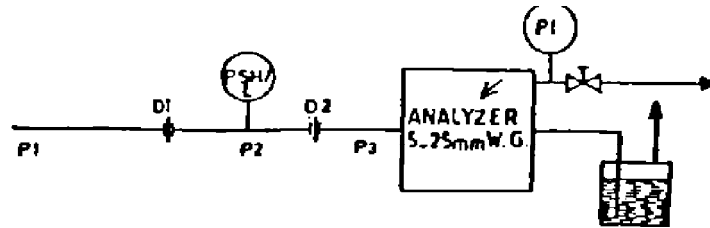
APPENDIX A1
PAGE 2 of 4

DIFFERENT PURGE SYSTEMS FOR ANALYZER EQUIPMENT



APPENDIX A1
PAGE 3 of 4

CALCULATION EXAMPLE OF RESTRICTION ORIFICES FOR INSTRUMENT CASING
PURGE SYSTEM



EXAMPLE 1 (FOR SYSTEM A)

P3 = 1 BARA

PURGE FLOW REQUIRED Q=10 l/min

AVAILABLE PURGE PRESSURE 7.0 bara (5.5 bara minimum)

SELECT R.O. d_1 TO GIVE ADEQUATE FLOW AT CRITICAL PRESSURE

DROP $\frac{P_1}{P_2} \mu 2$ FROM SIZING NOMOGRAM IN APPENDIX A1 Page 4 of 4

RESULTING R.O. $d_1 = 0.6 \text{ mm}$ $Q = 11.5 \text{ l/min}$

SELECT R.O. d_2 such that $\frac{P_1}{P_2} \mu 2$

ELECTED R.O. $d_2 = 0.9 \text{ mm}$ RESULTS IN $P = 1.3 \text{ kg/cm}^2$

HENCE $P_2 = P_3 + \Delta P = 1.0 + 1.3 = 2.3 \text{ bar}$ WHICH IS LESS THAN $\frac{7}{2} = 3.5 \text{ bar}$

Note:

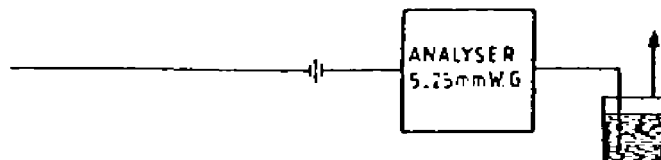
That also R.O. with $d = 0.8 \text{ mm}$ gives critical flow $\frac{P_2}{P_3} > 2$

OTHER POSSIBLE DIAMETERS FOR R.O.2 ARE 1.1 mm OR 1.0 mm

RESULTING IN $P_2 = 1.0 + 0.55 = 1.55 \text{ bar}$ and

$P_2 = 1.0 + 0.8 = 1.8 \text{ bar}$

EXAMPLE 2 (FOR SYSTEM B, C OR D)



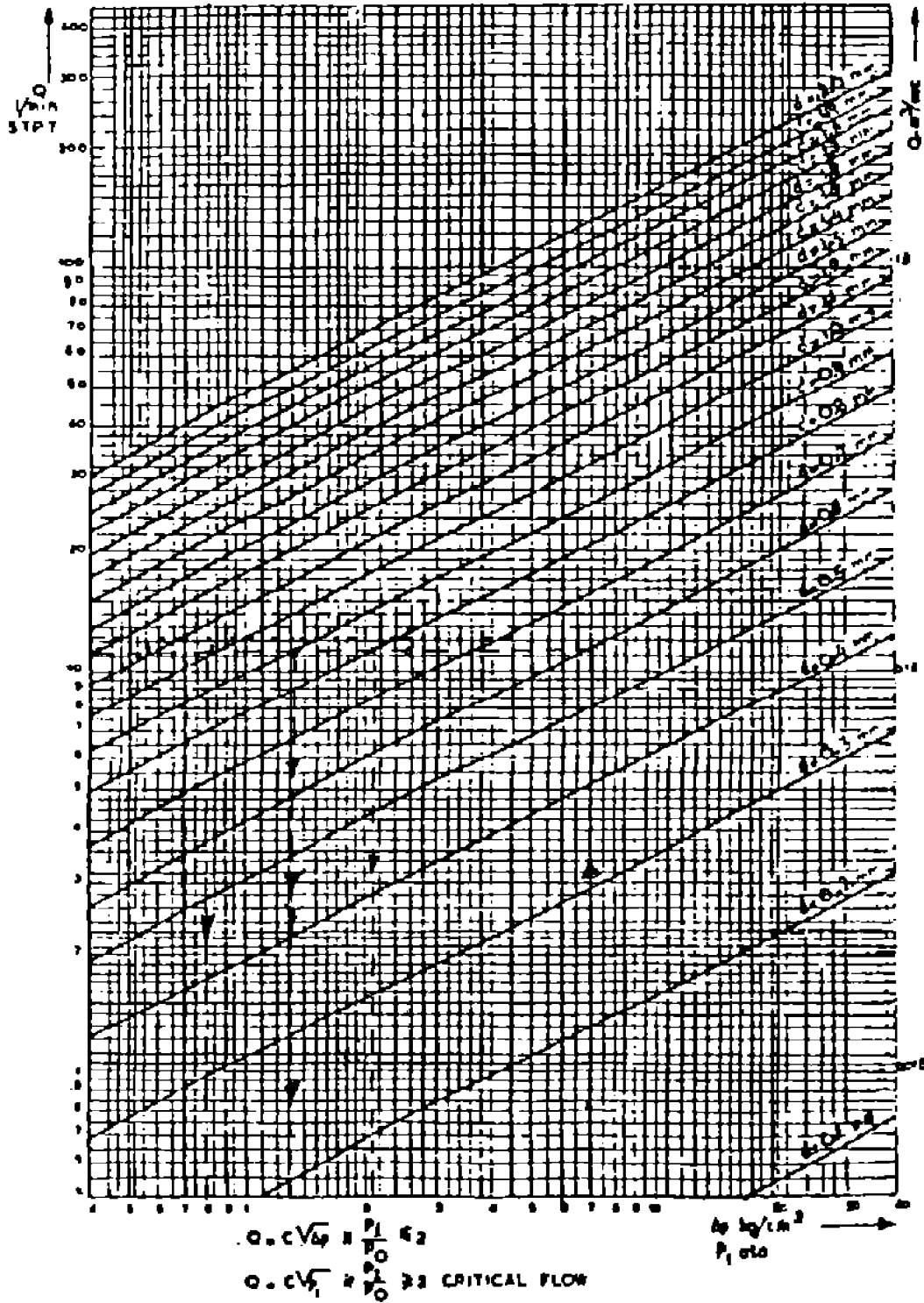
PURGE FLOW REQUIRED $Q = 10 \text{ l/min}$

AVAILABLE PURGE PRESSURE 7.0 bar (5.5 bar minimum)

SELECTED R.O. FROM APPENDIX A1 Page 4 of 4 $d = 0.6 \text{ mm}$.

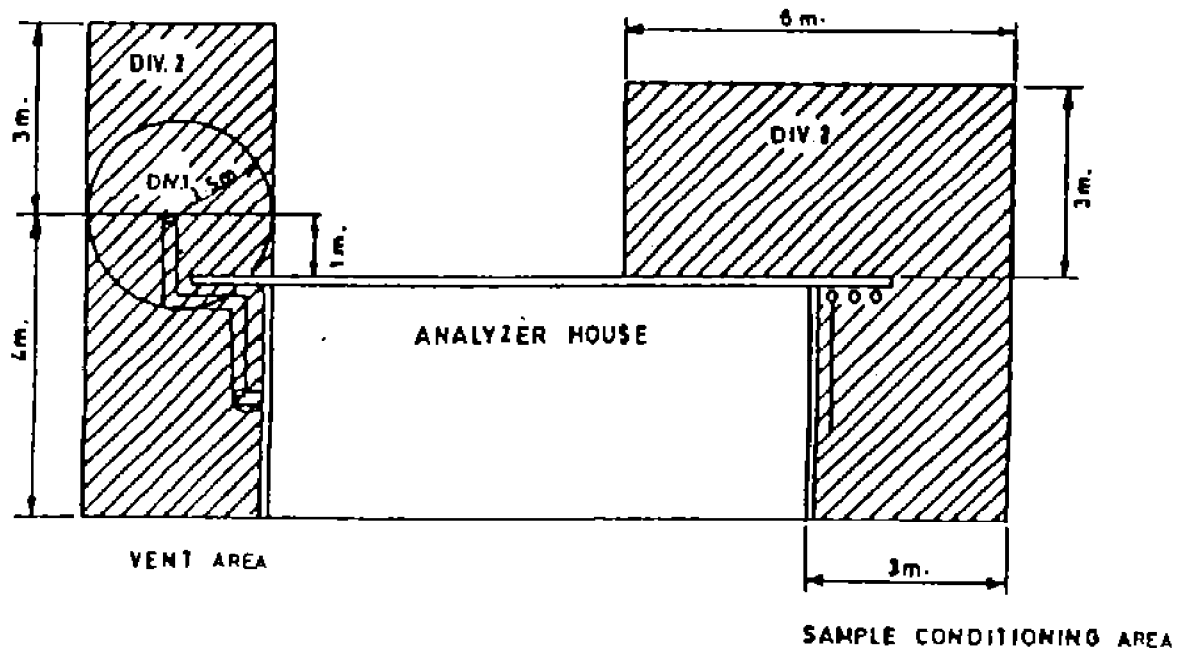
APPENDIX A1
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SIZING NOMOGRAM CONICAL ENTRANCE RESTRICTION
ORIFICES FOR AIR AND NITROGEN



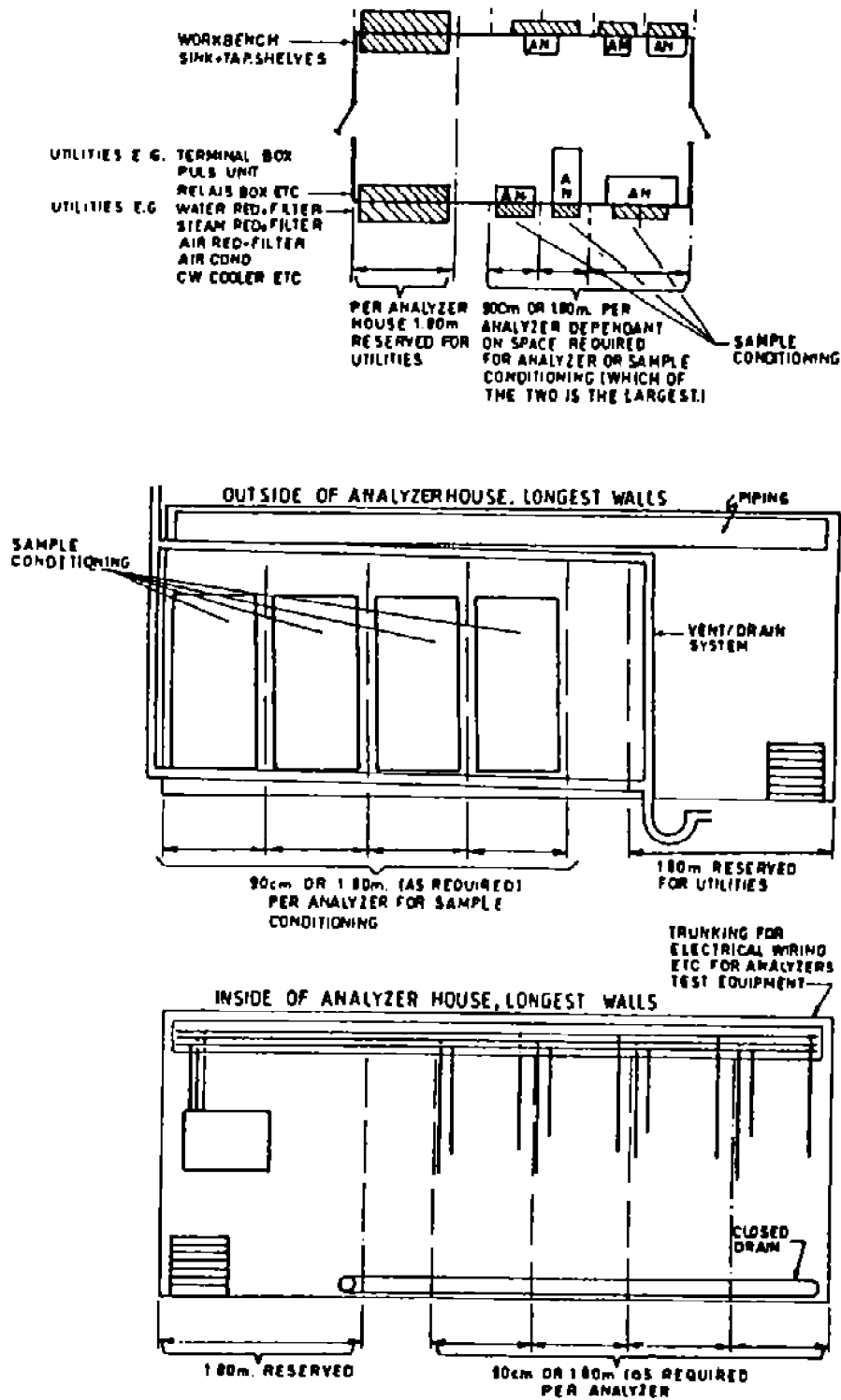
APPENDIX A2
PAGE 1 of 1

AREA CLASSIFICATION AROUND ANALYZER HOUSE



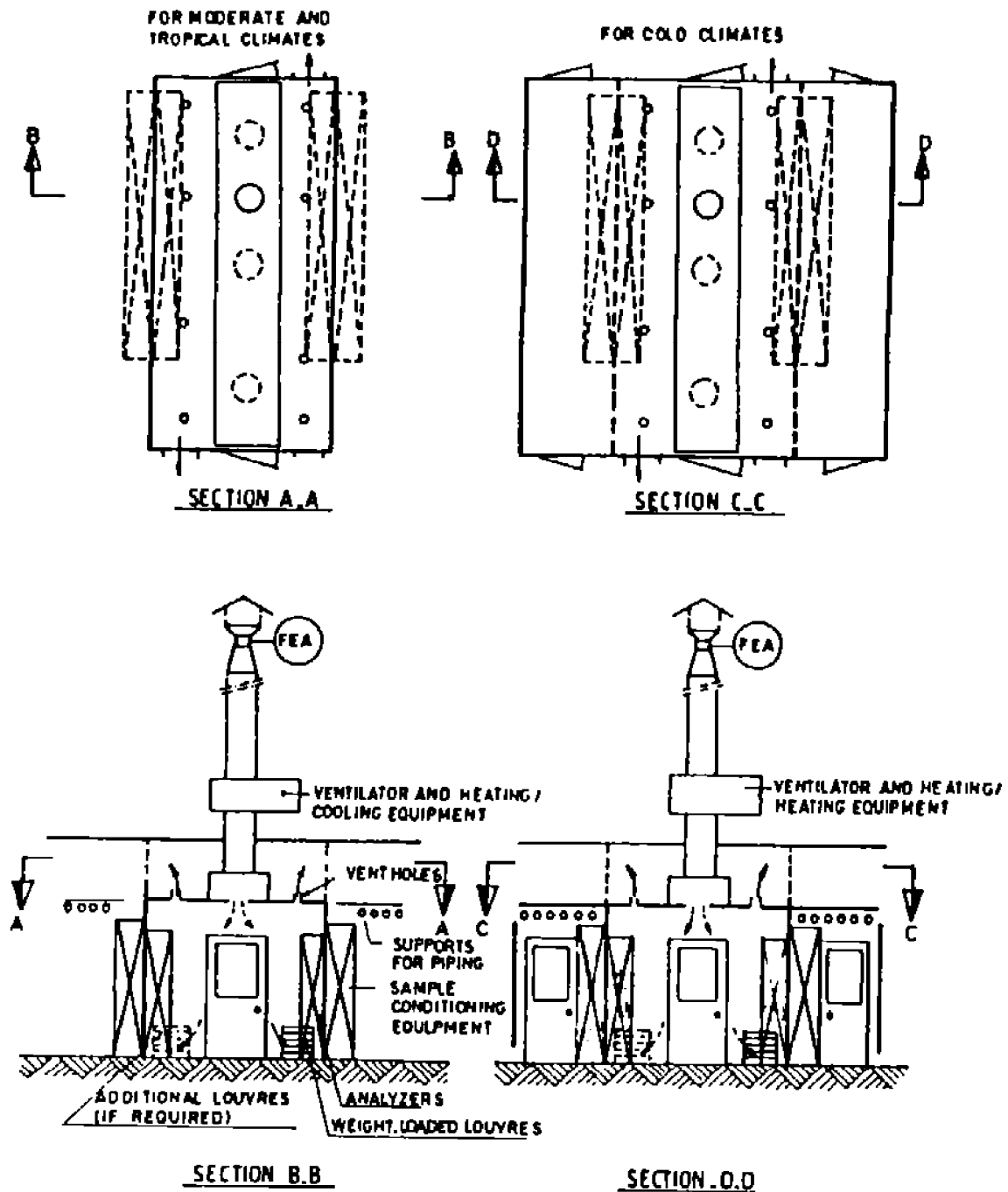
APPENDIX A3
PAGE 1 of 2

TYPICAL ARRANGEMENT OF EQUIPMENT IN ANALYZER HOUSE



APPENDIX A3
PAGE 2 of 2

TYPICAL ARRANGEMENT OF ANALYZER HOUSE

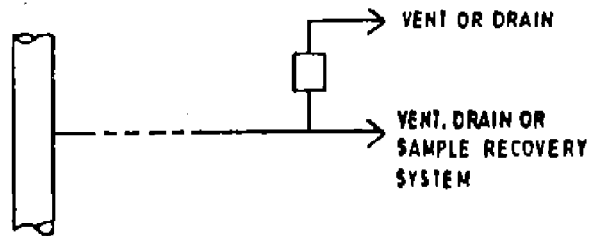


Note:

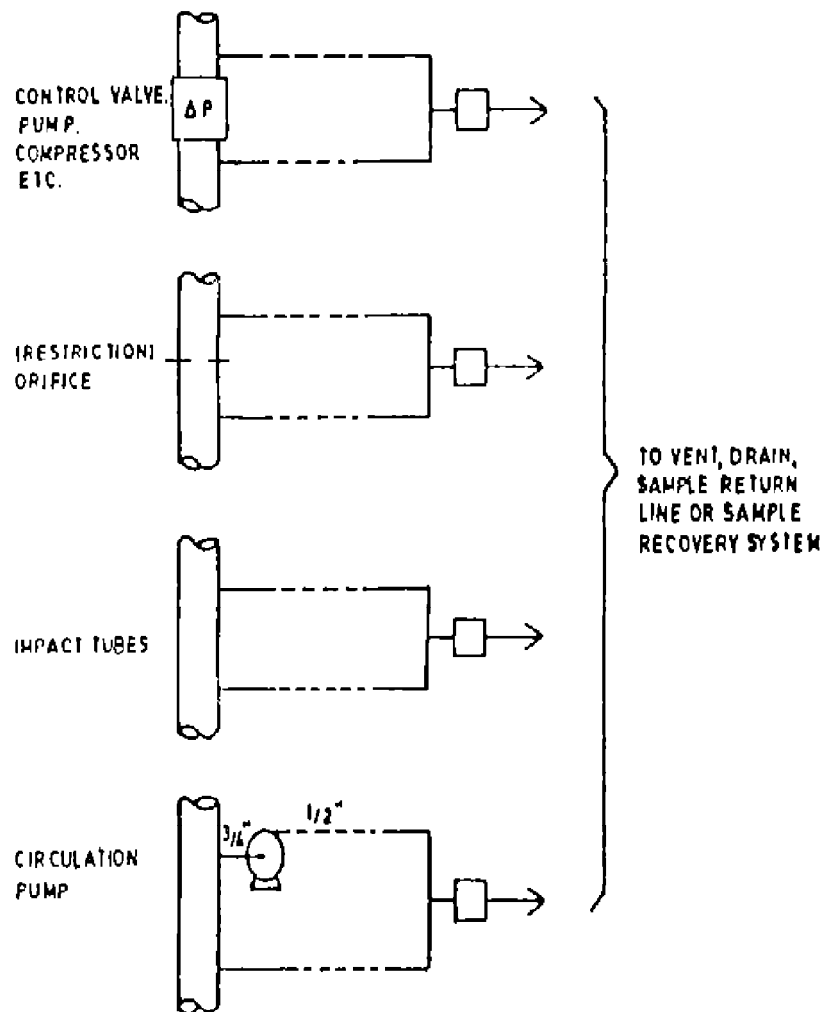
- 1) FEA = Flow Element and Annunciator.
- 2) For cold climate separate enclosures shall be added to the analyzer house to accommodate the sample conditioning system.

APPENDIX A4

SAMPLE TRANSPORT SYSTEM

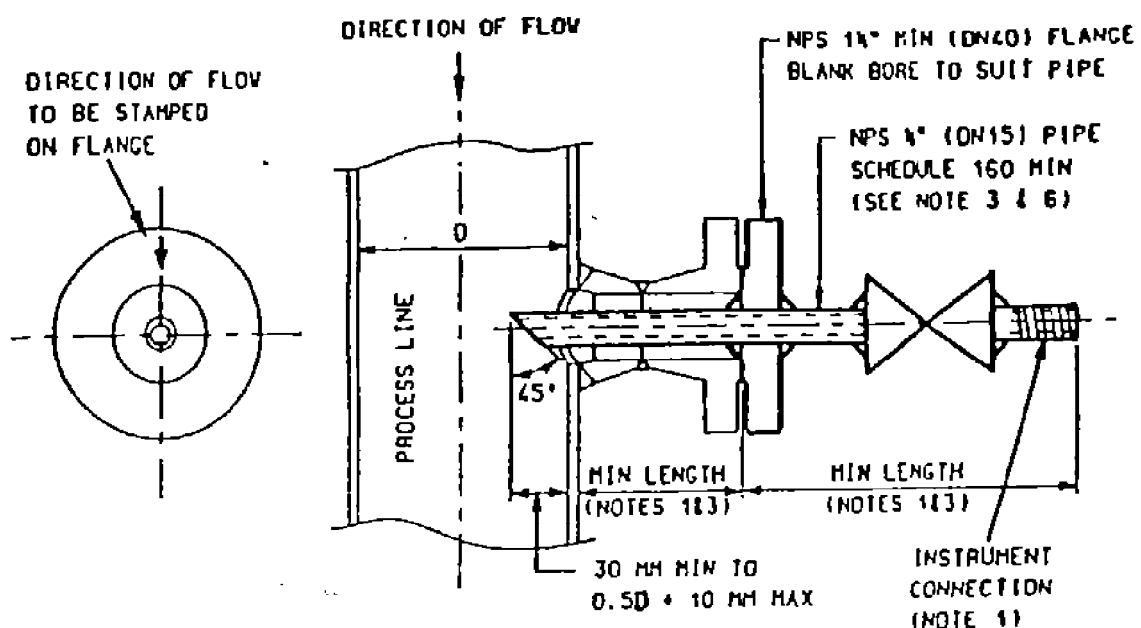


FAST LOOP SYSTEMS



APPENDIX A5

TYPICAL ANALYZER SAMPLING PROBE
FOR LINE SIZES NPS 2" & ABOVE

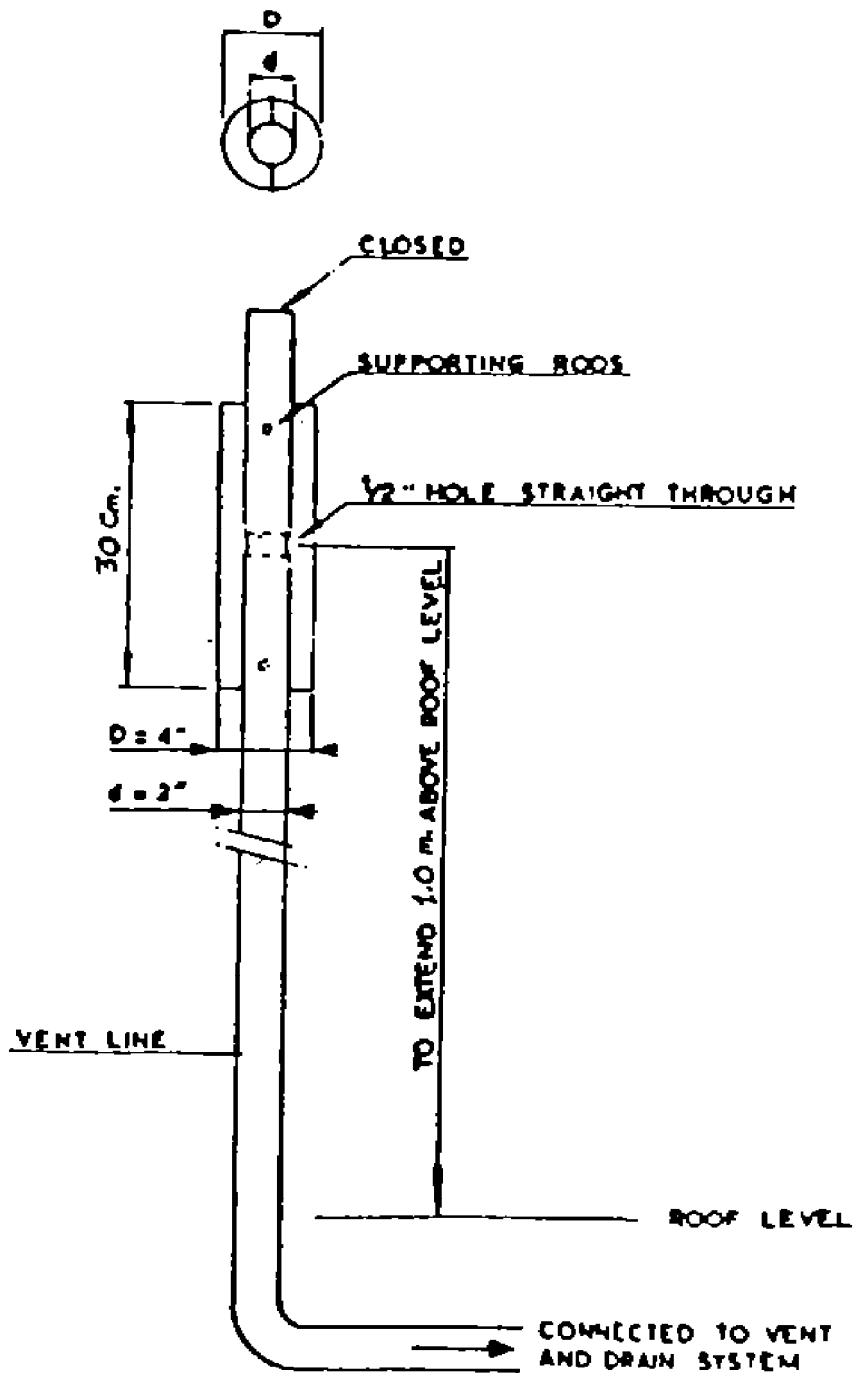


Notes:

- 1) All materials, flange type, pipe fittings, valves, class rating, branch connection details, instrument connection, welding details and heat treatment shall comply with relevant piping specifications.
- 2) The probe shall not be installed in the bottom of process lines; to avoid dirt, water entrainment in sample.
- 3) The contained volume of the probe shall be minimized by limiting the dimensions as given above. Where necessary, double valving shall be provided. When the liquid sample is to be vaporized, double extra strong pipe and reduced bore valve shall be used.
- 4) The flange shall be stamped with the probe tag number and flow direction.
- 5) This probe is only recommended for single phase process sampling.
- 6) For fast loop service, the probe size, and if necessary the branch connection, may be increased to meet loop flow requirements.
- 7) Care must be taken with the design of the probe to ensure it will not fail due to resonance effects.

APPENDIX A6

TYPICAL VENT LINE CONSTRUCTION



Note:

For common vent and drain system on analyzer houses refer to Appendix A7.

ANALYZER HOUSE VENT AND DRAIN SYSTEM



APPENDIX B

OSHA SPECIFICATION FOR TOXIC GASES SAFE OCCUPATIONAL EXPOSURE LIMIT

NIOSH/OSHA SPECIFICATIONS FOR AIRBORNE CONTAMINANT LEVELS

CONTAMINANT	PEL (ppm)	IDLH (ppm)
AMMONIA	50	500
BENZENE	1 (5 CEILING)	2000
BROMINE	1	10
CARBON MONOXIDE	35	1500
CARBON DISULFIDE	10 (CEILING)	500
CHLORINE	1	25
CHLORINE DIOXIDE	0.1	10
HYDROGEN CHLORIDE	5 (CEILING)	100
HYDROGEN FLUORIDE	3	20
HYDROGEN SULFIDE	20 (CEILING)	300
METHYL MERCAPTAN	10	400
NITRIC OXIDE	25	100
NITRIC ACID	2	100
NITROGEN DIOXIDE	5	50
OZONE	0.1	10
PHOSGENE	0.1	2
PHTHALIC ANHYDRIDE	2	10,000
SULFUR DIOXIDE	5	100
TOLUENE	100	2,000

PEL : Permissible Exposure Limit, based on time - weighted average level.
IDLH : Immediately Dangerous to Life or Health.

APPENDIX C

TYPICAL ANALYZERS SAMPLE CONDITIONING SYSTEMS

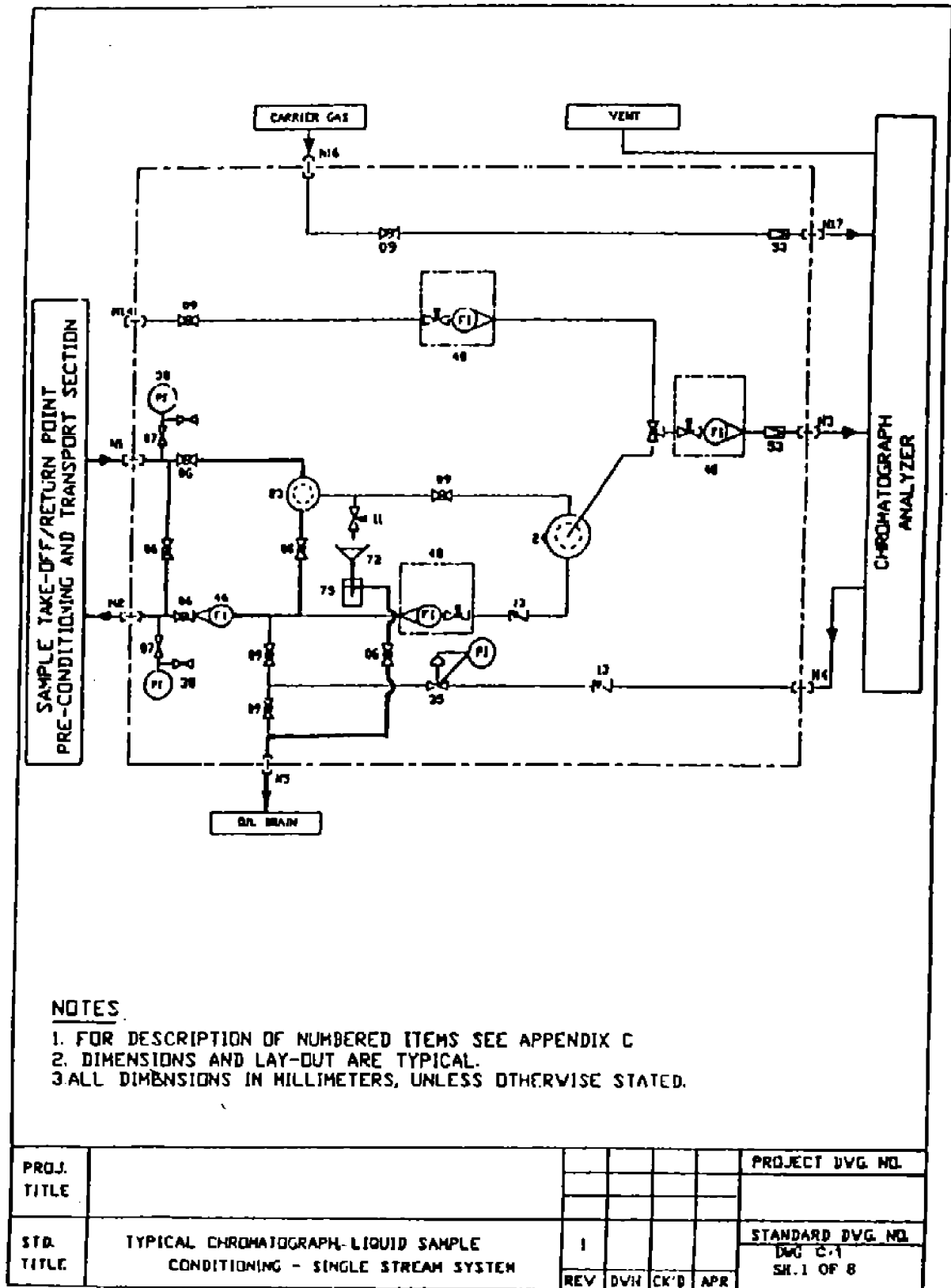
INDEX OF APPENDIX C

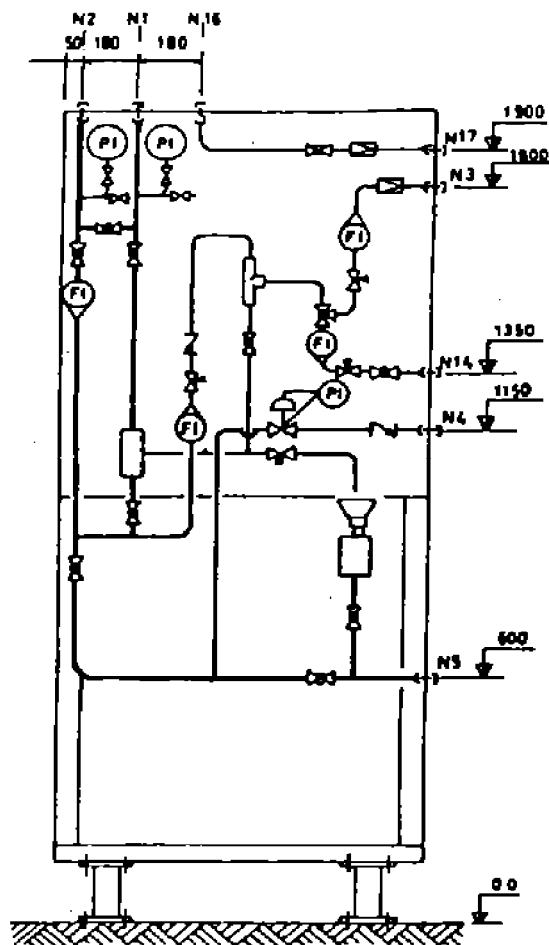
No. OF SHEETS

PART I: LIST OF DRAWINGS

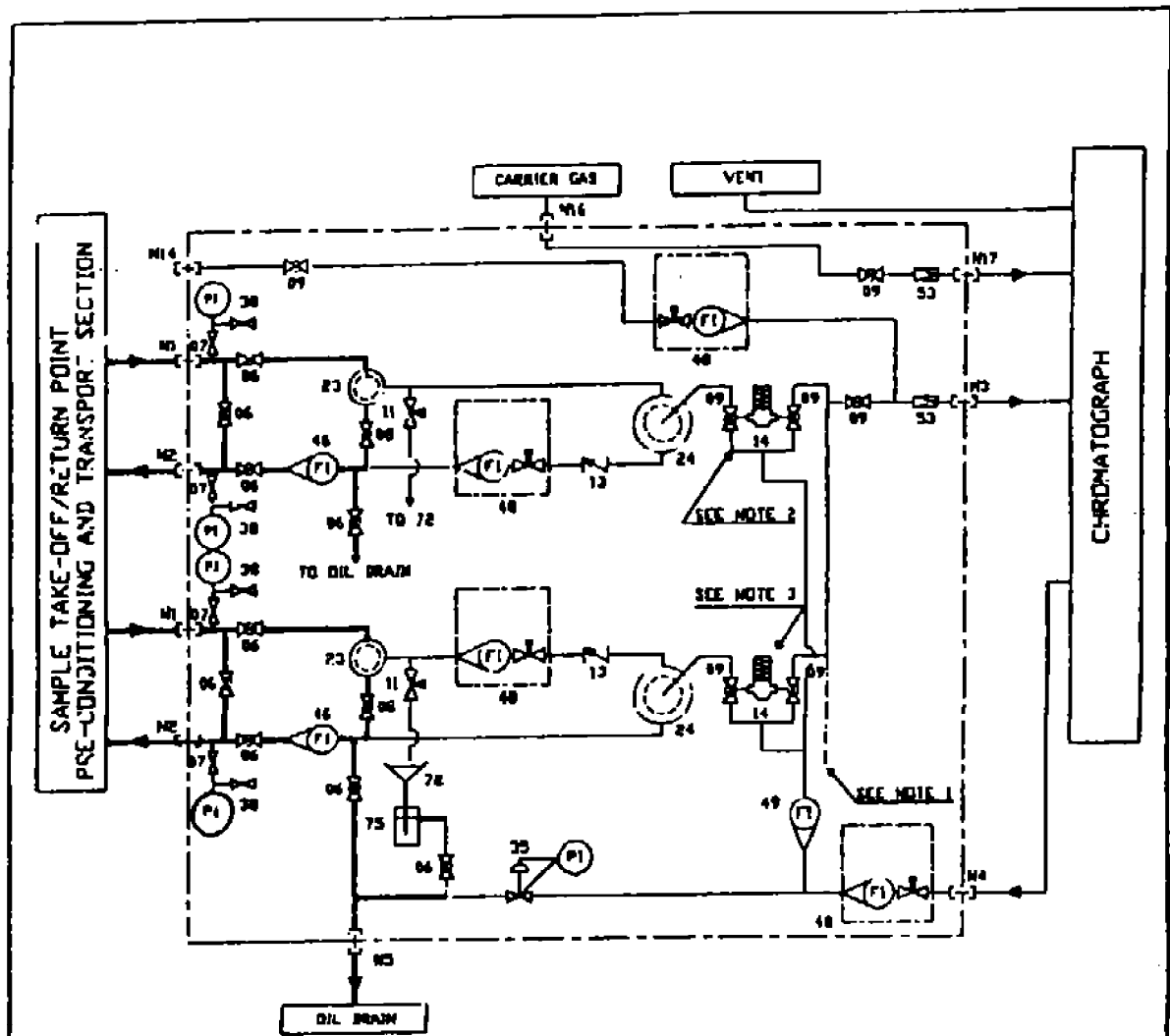
C.1	TYPICAL CHROMATOGRAPH-LIQUID AND GAS SAMPLE CONDITIONING-SINGLE AND MULTI STREAM SYSTEM	8
C.2	TYPICAL VISCOSITY SAMPLE CONDITIONING SYSTEM	2
C.3	TYPICAL DISTILLATION (FBP, FLASH POINT) SAMPLE CONDITIONING SYSTEM	2
C.4	TYPICAL FLASH POINT SAMPLE CONDITIONING SYSTEM WITH REFRIGERATION	2
C.5	TYPICAL POUR POINT SAMPLE CONDITIONING SYSTEM	1
C.6	TYPICAL CLOUD POINT SAMPLE CONDITIONING SYSTEM	2
C.7	TYPICAL KINETIC VAPOR PRESSURE SAMPLE CONDITIONING SYSTEM	2
C.8	TYPICAL OXYGEN SAMPLE CONDITIONING SYSTEM	2
C.9	TYPICAL N ₂ PURITY ANALYZER SAMPLE CONDITIONING SYSTEM	1
C.10	TYPICAL LIQUID DENSITY SAMPLE CONDITIONING SYSTEM WITH COOLING, FLUSHING OR BOTH	2
C.11	TYPICAL GAS DENSITY SAMPLE CONDITIONING SYSTEM	2
C.12	TYPICAL SULFUR AND H ₂ S ANALYZER SAMPLE CONDITIONING SYSTEM	1
C.13	TYPICAL WATER CONTENT SAMPLE CONDITIONING SYSTEM	2
C.14	TYPICAL MOISTURE SAMPLE CONDITIONING SYSTEM	1
C.15	TYPICAL PH CONDUCTIVITY SAMPLE CONDITIONING SYSTEM	2
C.16	TYPICAL STEAM PURITY SAMPLE CONDITIONING SYSTEM	1
C.17	TYPICAL DISSOLVED OXYGEN SAMPLE CONDITIONING SYSTEM	2
C.18	TYPICAL OIL-IN-WATER SAMPLE CONDITIONING SYSTEM	2
C.19	TYPICAL THERMAL CONDUCTIVITY SAMPLE CONDITIONING SYSTEM	2
C.20	TYPICAL SALT-IN-CRUDE SAMPLE CONDITIONING SYSTEM	1

PART II: COMPONENTS OF SAMPLE CONDITIONING SYSTEM USED IN THE TYPICAL DRAWINGS (C1 TO C20)





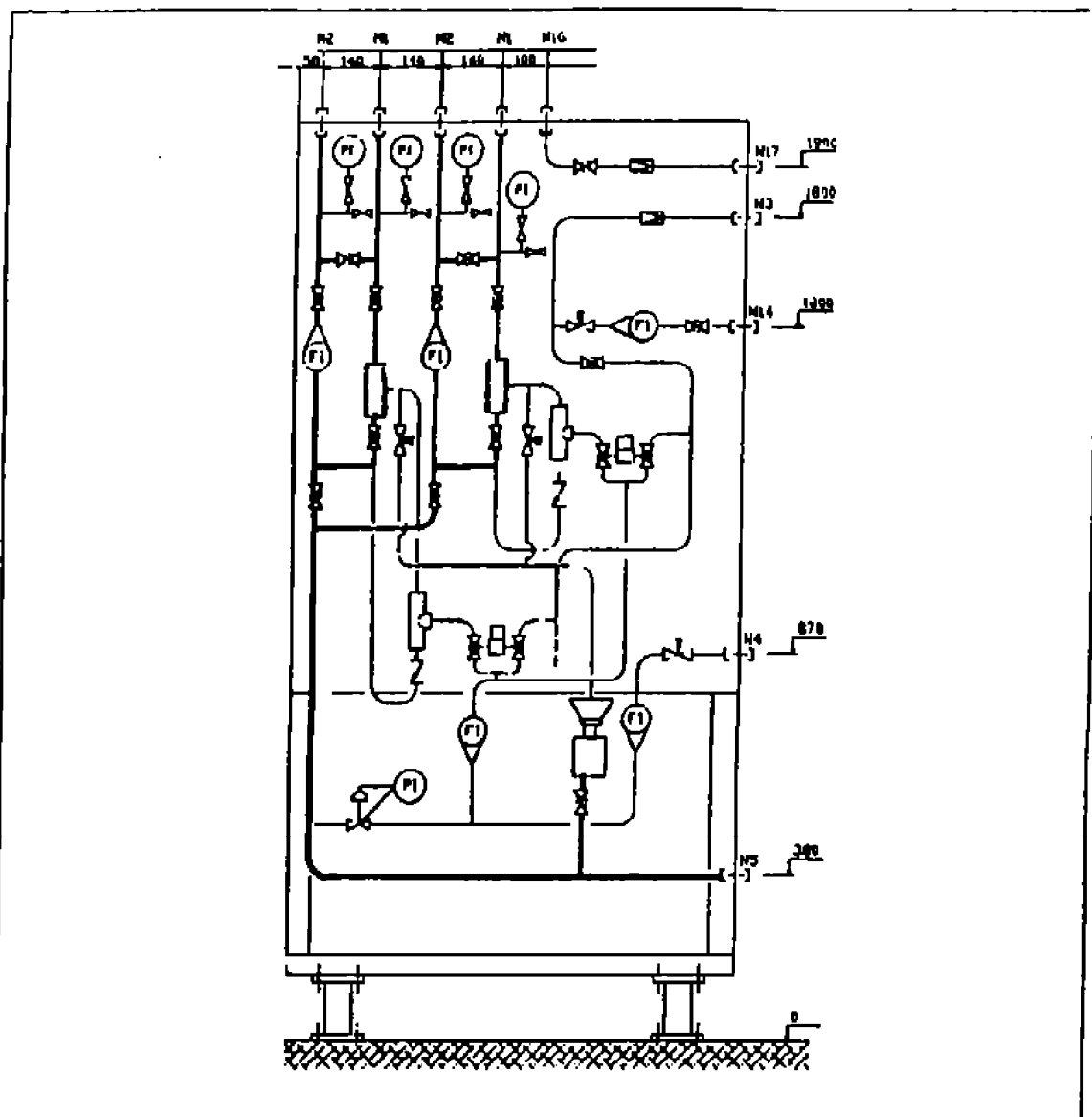
ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATERIAL	COMPRESSION TYPE	
N1	SAMPLE INLET	1/2" O.D.		BULKHEAD UNION	
N2	SAMPLE FASTLOOP OUTLET	1/2" O.D.		BULKHEAD UNION	
N3	SAMPLE OUTLET TO ANALYSER	1/8" O.D.		BULKHEAD UNION	
N4	SAMPLE RETURN FROM ANALYSER	1/8" O.D.		BULKHEAD UNION	
N5	OIL DRAIN	1/2" O.D.		BULKHEAD UNION	
N14	CALIBRATION SAMPLE	1/4" O.D.		BULKHEAD UNION	
N16	CARRIER GAS INLET	1/4" O.D.		BULKHEAD UNION	
N17	CARRIER GAS OUTLET TO ANALYSER	1/4" O.D.		BULKHEAD UNION	
PROJ.					PROJECT DWG. No.
TITLE					
STD.					STANDARD DWG. No.
TITLE	TYPICAL CHROMATOGRAPH, LIQUID SAMPLE CONDITIONING SINGLE STREAM SYSTEM	0	A.P.		DWG. C-1
		REV.	OWN	CK'D	APR
					SH 2 OF 8



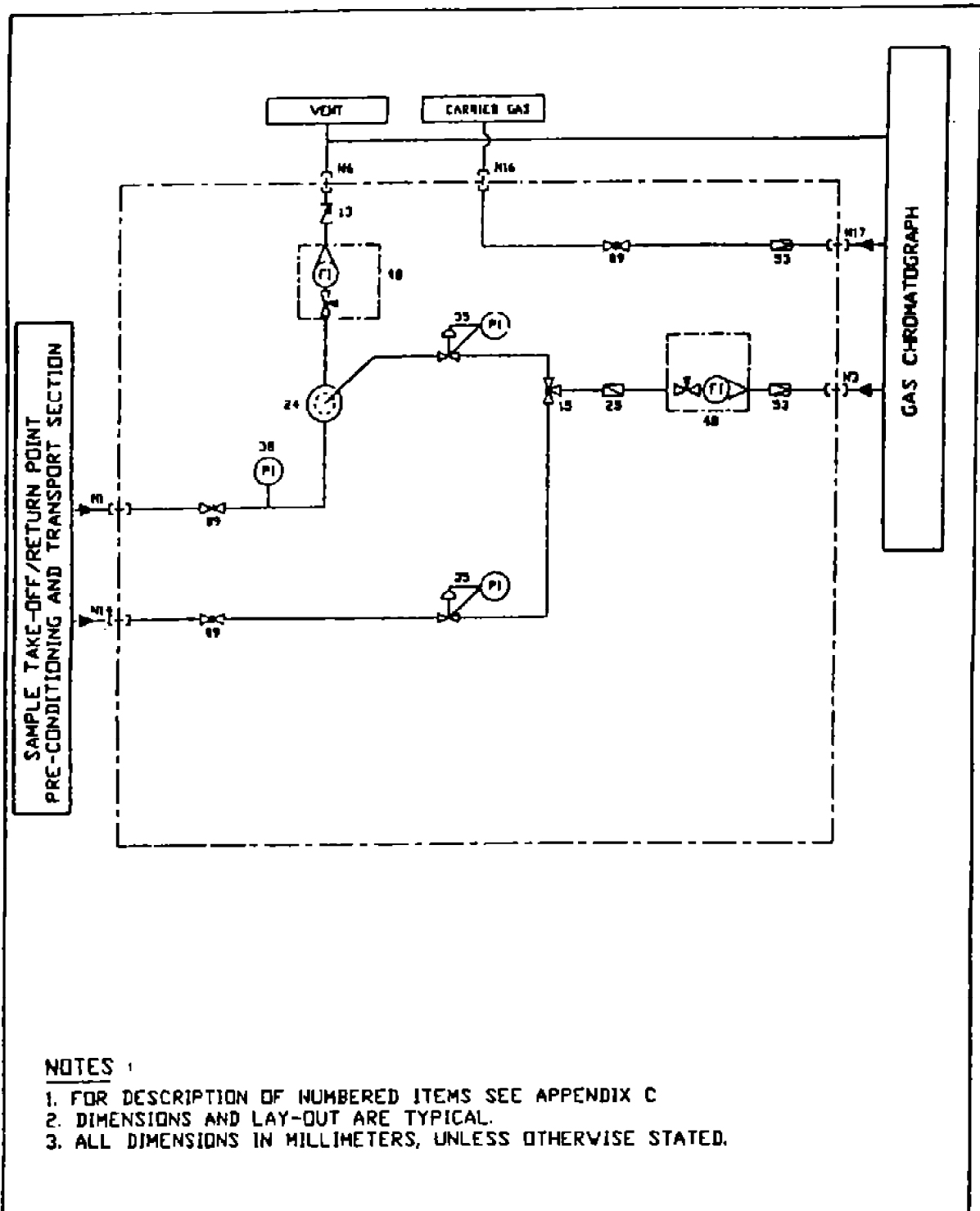
NOTES:

1. FOR NUMBER OF SAMPLE STREAMS SEE REQUISITION.
2. TWO BALL VALVES OPERATED BY ONE PNEUMATIC ACTUATOR.
3. PNEUMATIC OPERATED VALVES TO BE OPERATED BY SOLENOID VALVES FROM STREAM SELECTOR OF PROCESS CHROMATOGRAPH.
4. FOR DESCRIPTION OF NUMBERED ITEMS SEE APPENDIX C
5. DIMENSIONS AND LAY-OUT ARE TYPICAL.
6. ALL DIMENSIONS IN MILLIMETERS, UNLESS OTHERWISE STATED.

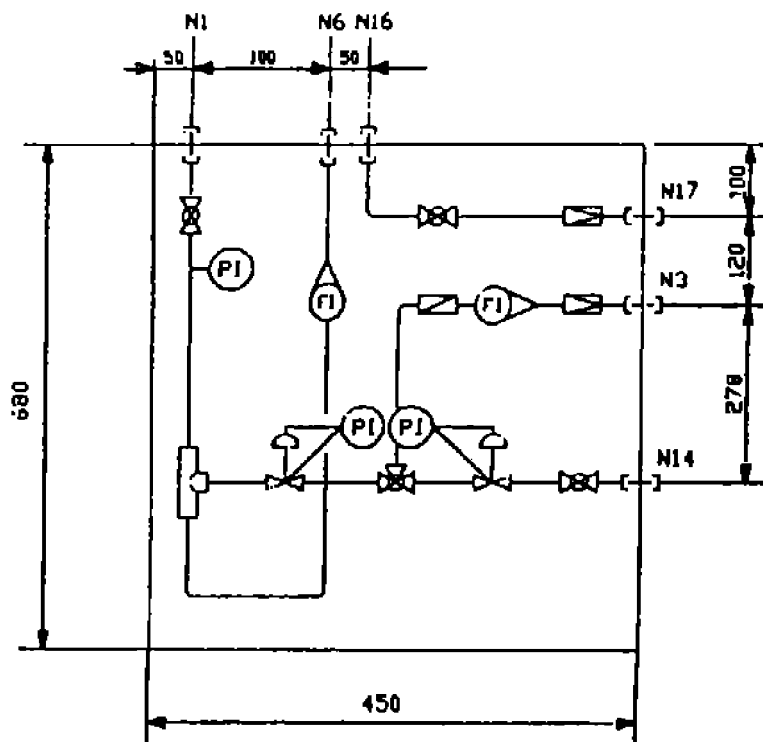
PROJ. TITLE					PROJECT DWG. NO.
STD. TITLE	TYPICAL CHROMATOGRAPH LIQUID SAMPLE CONDITIONING-MULTI STREAM SYSTEM	1			STANDARD DWG. NO.
		REV	DWN	CK'D	APR
					DWG C-1
					SHD OF 8



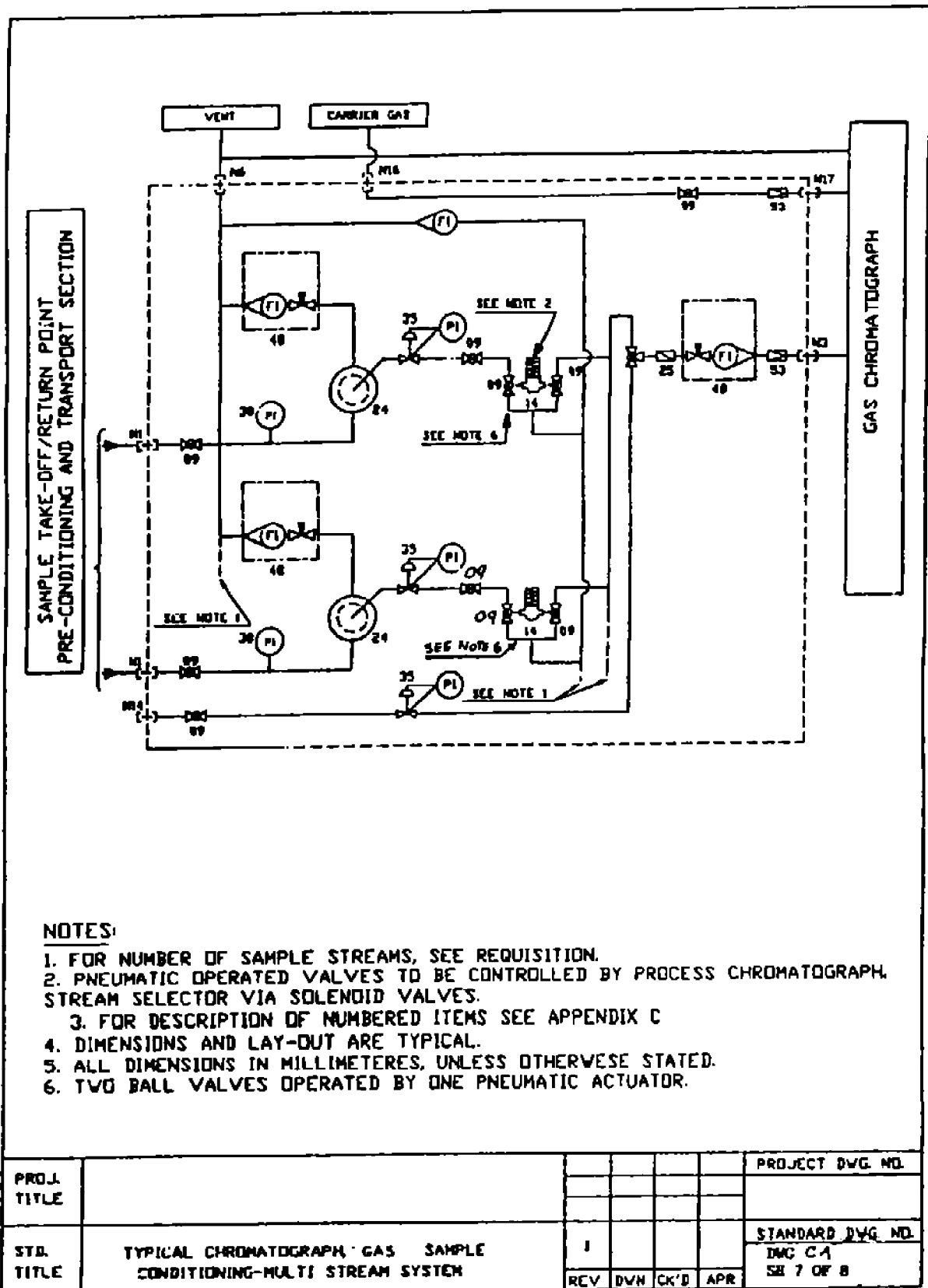
ITEM.	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE FASTLOOP INLET	1/2"OD		BULKHEAD UNION
N2	SAMPLE FASTLOOP OUTLET	1/2"OD		BULKHEAD UNION
N3	SAMPLE TO ANALYZER	1/4"OD		BULKHEAD UNION
N4	SAMPLE RETURN FROM ANALYZER	1/4"OD		BULKHEAD UNION
N5	OIL DRAIN	1/2"OD		BULKHEAD UNION
N14	CALIBRATION SAMPLE INLET	1/4"OD		BULKHEAD UNION
N16	CARRIER GAS INLET	1/4"OD		BULKHEAD UNION
N17	CARRIER GAS TO ANALYZER	1/4"OD		BULKHEAD UNION
PROJ. TITLE				PROJECT DWG. NO.
STD. FILE	TYPICAL CHROMATOGRAPH LIQUID SAMPLE CONDITIONING-MULTI STREAM SYSTEM	1		STANDARD DWG. NO.
		REV	DWG	CHK'D
			APR	
				DWG C-1
				SB 4 OF 8

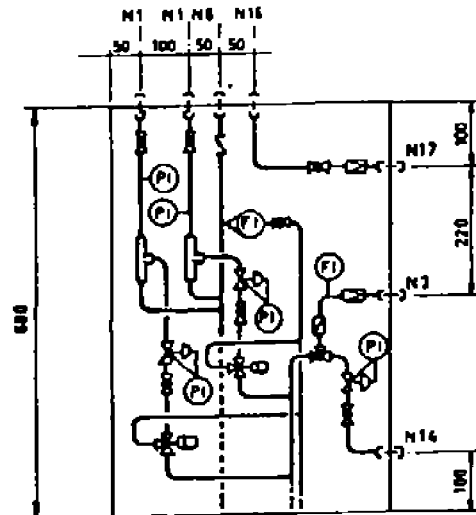


PROJ. TITLE					PROJECT DVG. NO.
STD. TITLE	TYPICAL CHROMATDGRAPH-GAS SAMPLE CONDITIONING SYSTEM - SINGLE STREAM	1			STANDARD DVG. NO. DVG C-1 SH 5 OF 8
		REV	DVN	CK'D	APR

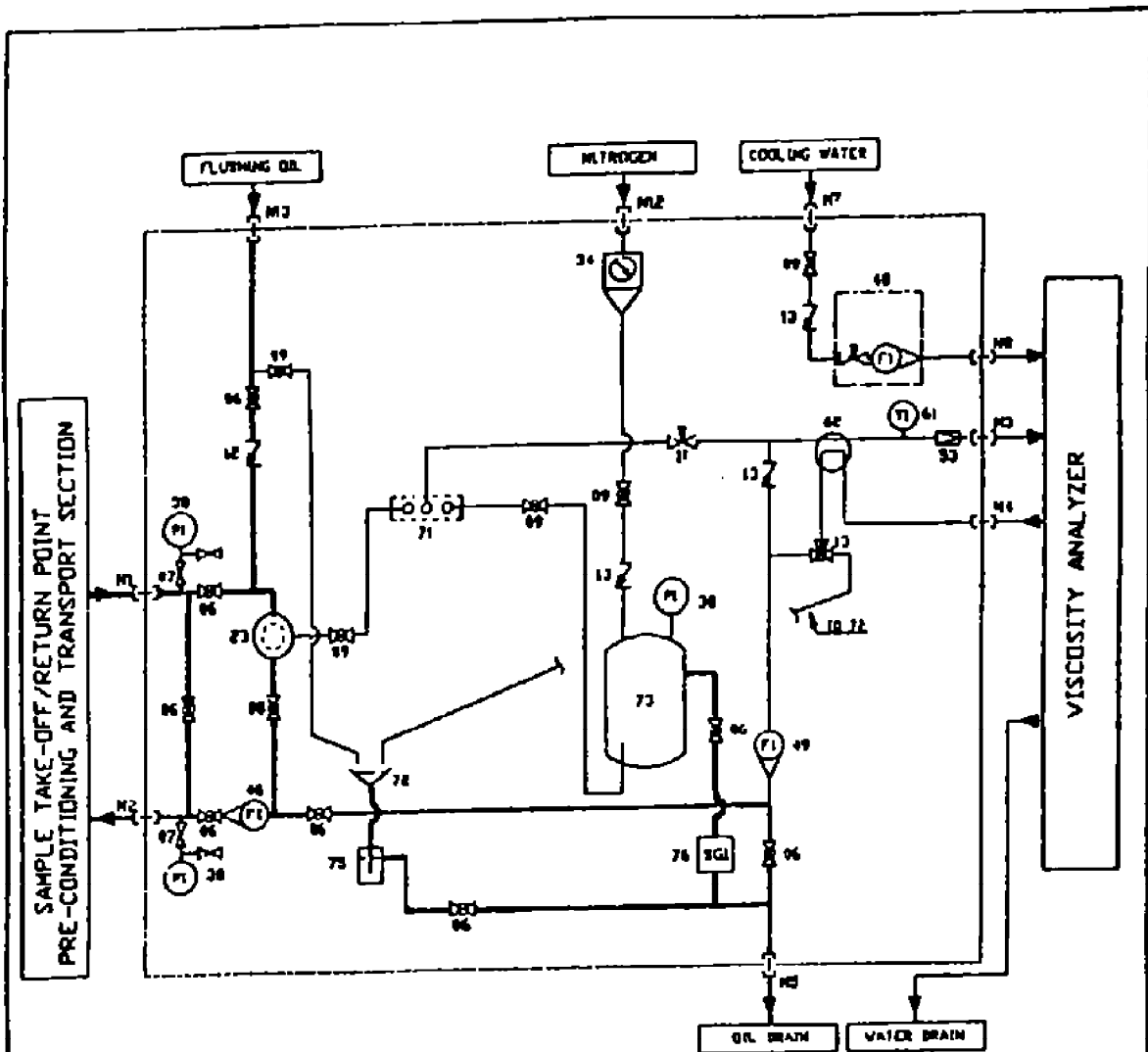


ITEM.	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE INLET	1/4"O.D.		BULKHEAD UNION
N3	SAMPLE TO ANALYZER	1/8"O.D.		BULKHEAD UNION
N6	SAMPLE TO VENT	1/4"O.D.		BULKHEAD UNION
N14	CALIBRATION SAMPLE INLET	1/4"O.D.		BULKHEAD UNION
N16	CARRIER GAS INLET	1/4"O.D.		BULKHEAD UNION
N17	CARRIER GAS ANALYZER	1/4"O.D.		BULKHEAD UNION
PROJ. TITLE				PROJECT DWG. NO.
STD. TITLE	TYPICAL CHROMATOGRAPH-GAS SAMPLE CONDITIONING SYSTEM-SINGLE STREAM	1		STANDARD DWG. NO.
		REV	DEVN	CK'D
			APR	
				DWG C-1
				SH 6 OF 8





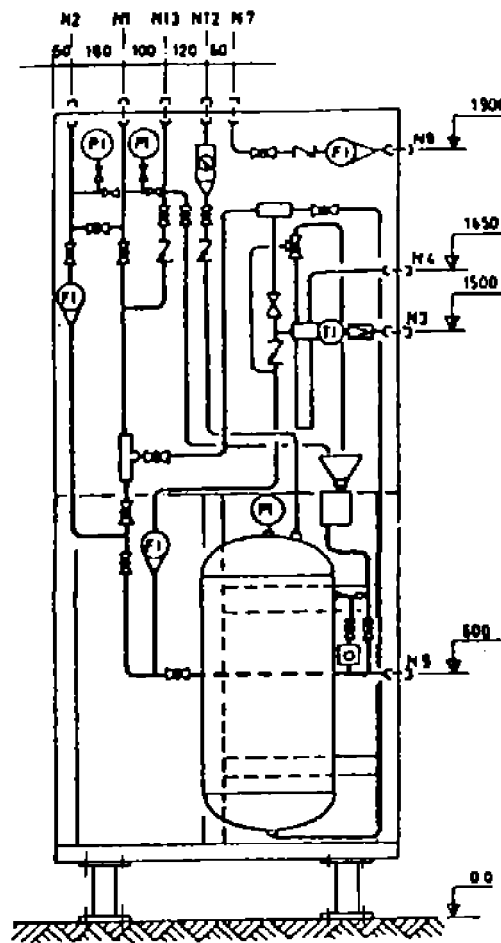
ITEM.	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE INLET	1/4" O.D.		BULKHEAD UNION
N3	SAMPLE TO ANALYZER	1/8" O.D.		BULKHEAD UNION
N6	SAMPLE TO VENT	1/4" O.D.		BULKHEAD UNION
N14	CALIBRATION SAMPLE INLET	1/4" O.D.		BULKHEAD UNION
N16	CARRIER GAS INLET	1/4" O.D.		BULKHEAD UNION
N17	CARRIER GAS TO ANALYZER	1/4" O.D.		BULKHEAD UNION
PROJ. TITLE				PROJECT DWG. No.
STD. TITLE	TYPICAL CHROMATOGRAPH GAS SAMPLE CONDITIONING SYSTEM-MULTI STREAM	0	A.P.	STANDARD DWG. No.
		REV	DWN	DWG C-1
			CK'D	SH 8 OF 8



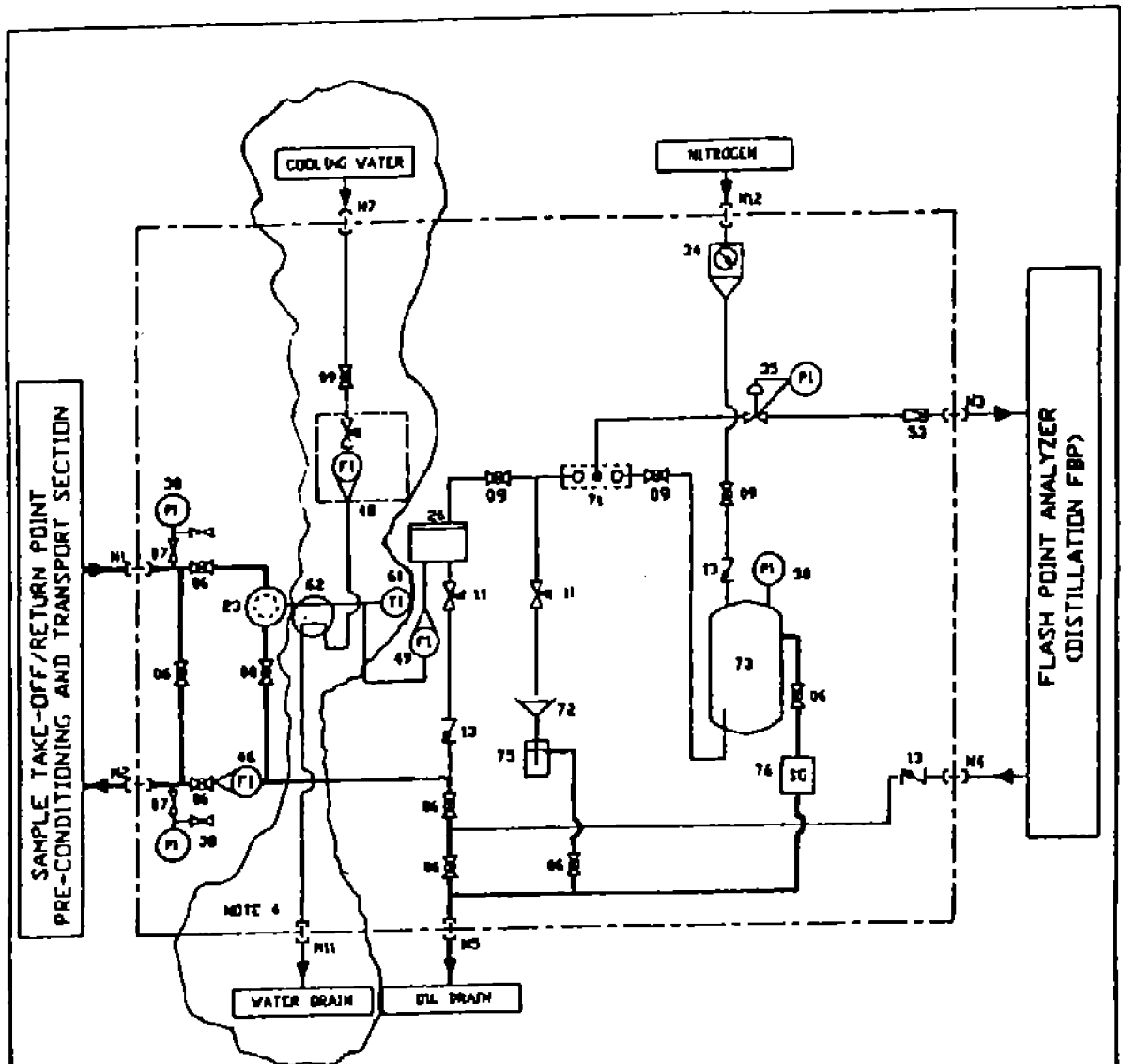
NOTES:

1. CALIBRATION VESSEL TO BE PROVIDED WITH EXTERNAL HEATING
2. FOR DESCRIPTION OF NUMBERED ITEMS SEE APPENDIX C
3. DIMENSIONS AND LAY-OUT ARE TYPICAL
4. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED

PROJ. TITLE					PROJECT DVG. NO.
STD. TITLE	TYPICAL VISCOSITY SAMPLE CONDITIONING SYSTEM	1			STANDARD DVG. NO.
		REV	DWN	CK'D	APR
					DWG C-2 SH 1 OF 2



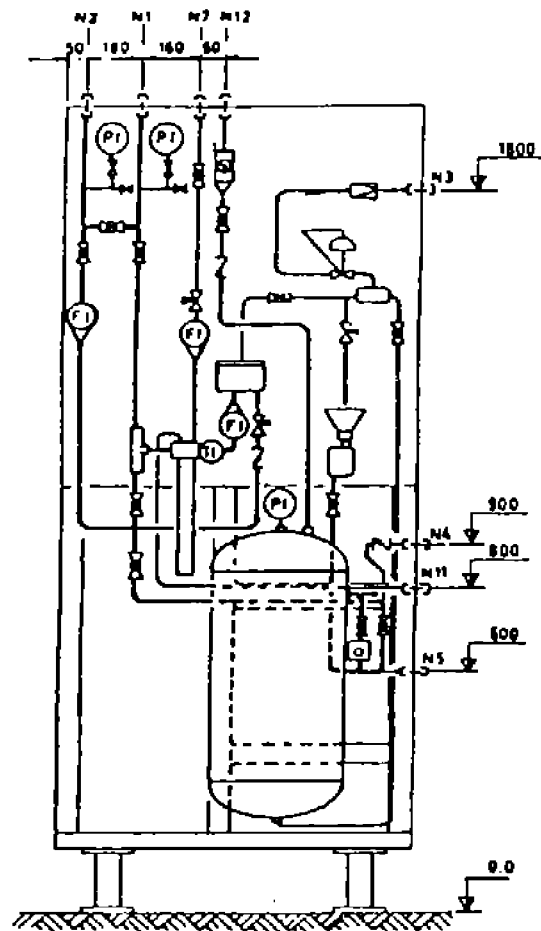
ITEM	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE FASTLOOP INLET	1/2" O.D.		BULKHEAD UNION
N2	SAMPLE FASTLOOP OUTLET	1/2" O.D.		BULKHEAD UNION
N3	SAMPLE TO ANALYZER	1/4" O.D.		BULKHEAD UNION
N4	SAMPLE RETURN FROM ANALYZER	1/4" O.D.		BULKHEAD UNION
N5	OIL DRAIN	1/2" O.D.		BULKHEAD UNION
N7	COOLING WATER INLET	1/4" O.D.		BULKHEAD UNION
N8	COOLING WATER TO ANALYZER	1/4" O.D.		BULKHEAD UNION
N12	NITROGEN INLET	1/4" O.D.		BULKHEAD UNION
N13	FLUSHING INLET	1/2" O.D.		BULKHEAD UNION
PROJ				PROJECT DWS No.
TITLE				
STD.	TYPICAL VISCOSITY SAMPLE CONDITIONING SYSTEM	0	A. P.	STANDARD DWS No.
TITLE		REV.	OWN	CHK'D
			APR.	
				DWG C-2 SM 2 OF 2



NOTES

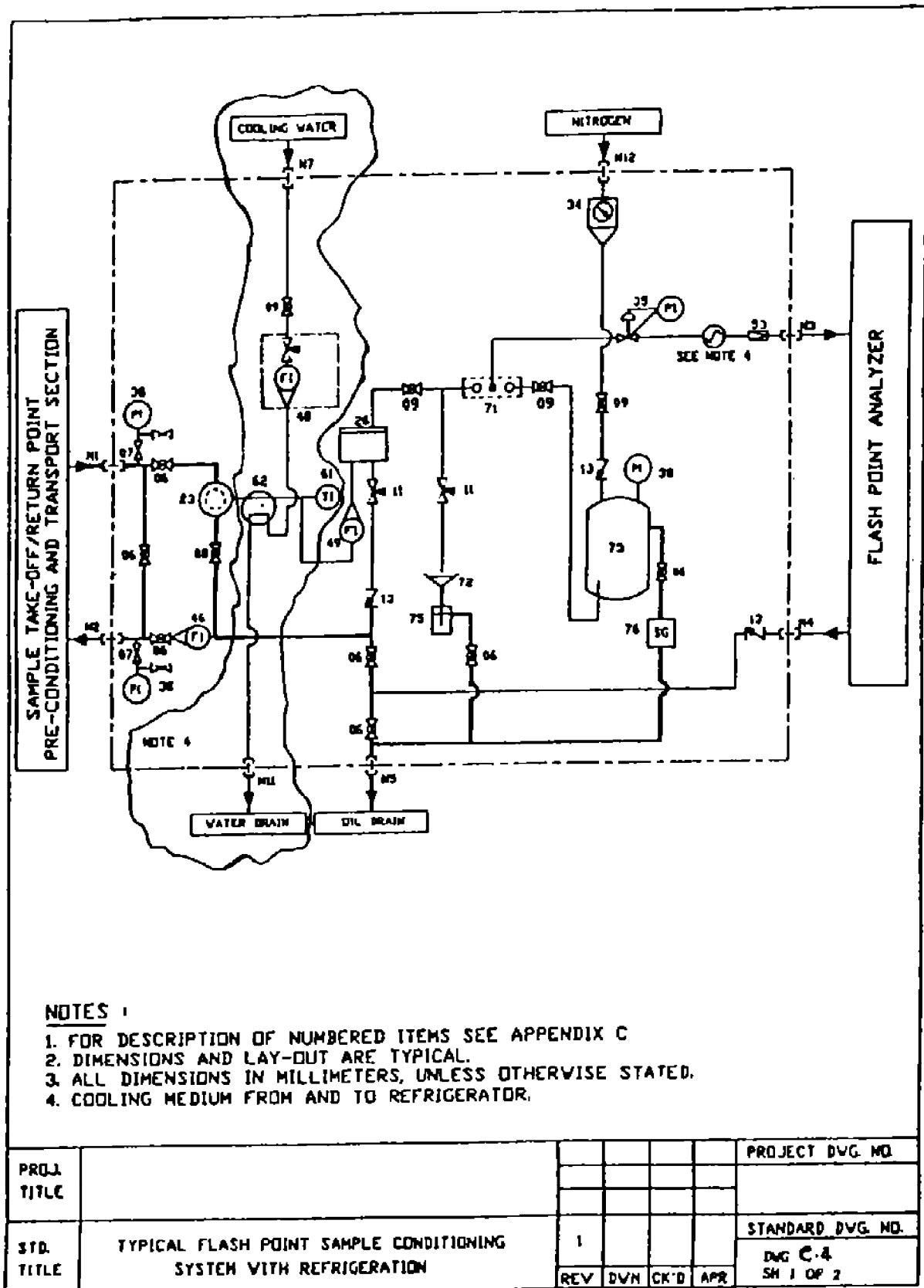
1. FOR DESCRIPTION OF NUMBERED ITEMS SEE APPENDIX C
2. DIMENSIONS AND LAY-OUT ARE TYPICAL.
3. DIMENSIONS IN MILLIMETERS, UNLESS OTHERWISE STATED.
4. TO BE DELETED IF COOLING OF SAMPLE IS NOT SPECIFIED

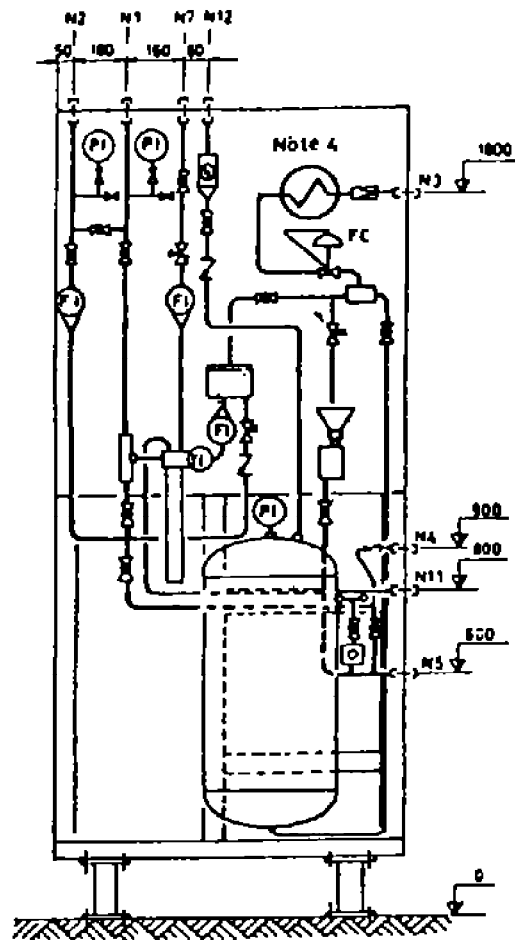
PROJ. TITLE		1	DVM	CK'D	APR	PROJECT DVG. NO.
STD. TITLE	TYPICAL DISTILLATION (FBP, FLASH POINT) SAMPLE CONDITIONING SYSTEM					STANDARD DVG. NO.
						DWG C-3 SH 1 OF 2



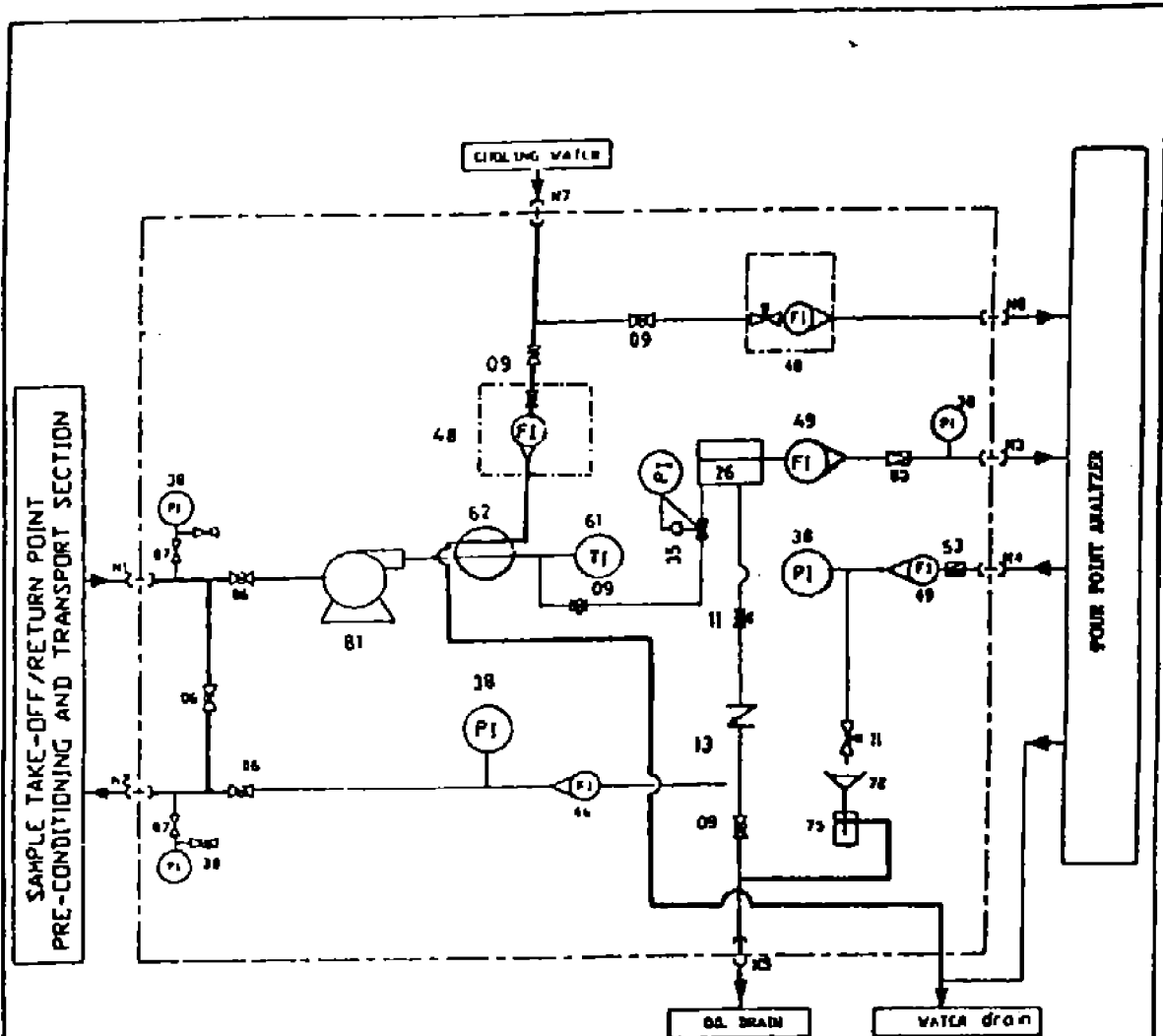
ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATERIAL	COMPRESSION TYPE	
N1	SAMPLE FASTLOOP INLET	1/2" O.D.		BULKHEAD UNION	
N2	SAMPLE FASTLOOP OUTLET	1/2" O.D.		BULKHEAD UNION	
N3	SAMPLE TO ANALYZER	1/4" O.D.		BULKHEAD UNION	
N4	SAMPLE RETURN FROM ANALYZER	1/4" O.D.		BULKHEAD UNION	
N5	OIL DRAIN	1/2" O.D.		BULKHEAD UNION	
N7	COOLING WATER INLET	1/4" O.D.		BULKHEAD UNION	
N11	WATER DRAIN	1/4" O.D.		BULKHEAD UNION	
N12	NITROGEN INLET	1/4" O.D.		BULKHEAD UNION	
PROJ TITLE					PROJECT DWG. No.
SID. TITLE	TYPICAL DISTILLATION (FBP, FLASH POINT) SAMPLE CONDITIONING SYSTEM	Q	A. R.		STANDARD DWG. No.
		REV.	OWN.	CK'D	APR

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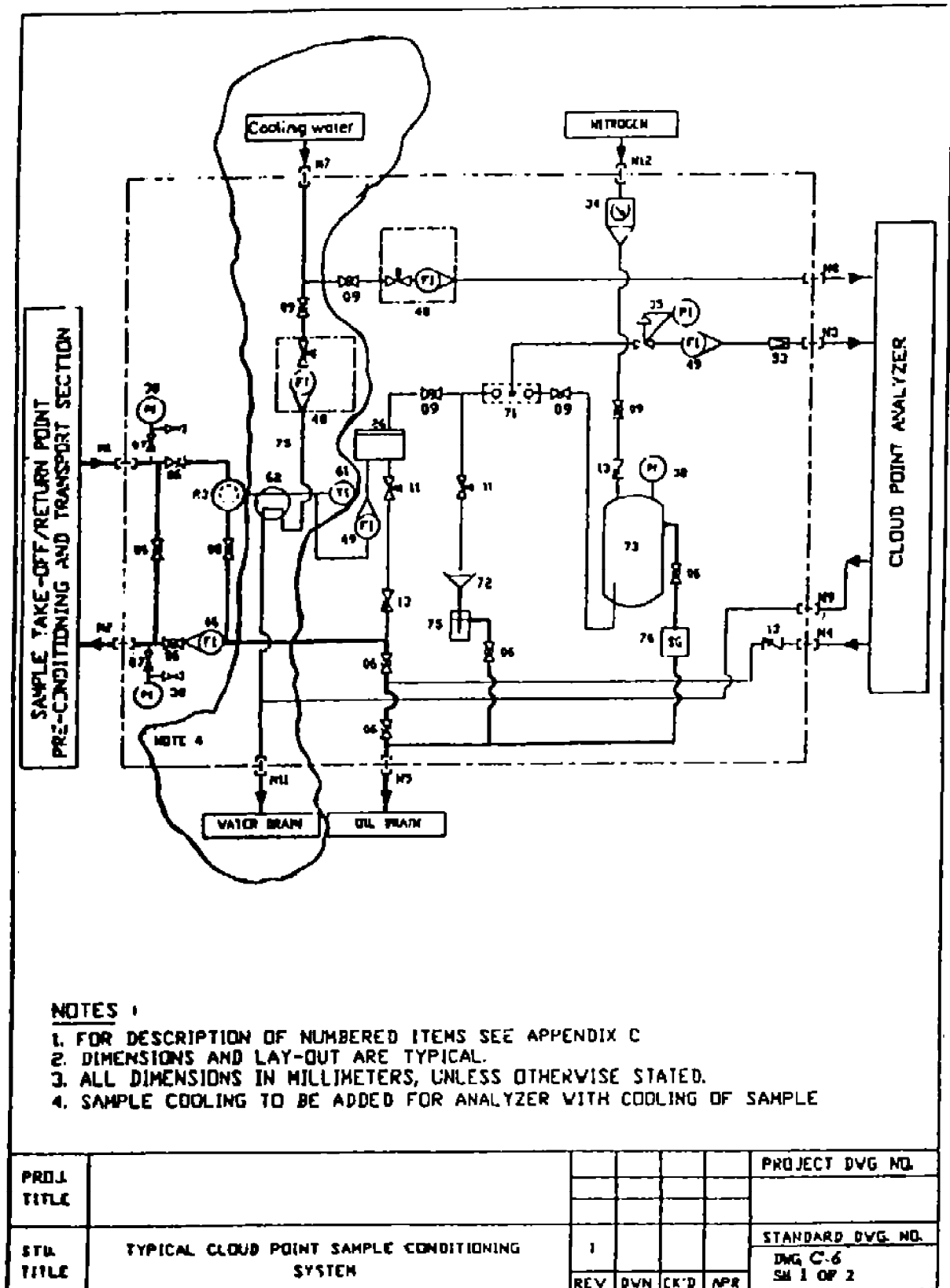
ITEM.	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE FASTLOOP INLET	1/2" O.D.		BULKHEAD UNION
N2	SAMPLE FASTLOOP OUTLET	1/2" O.D.		BULKHEAD UNION
N3	SAMPLE TO ANALYSER	1/4" O.D.		BULKHEAD UNION
N4	SAMPLE TO RETURN FROM ANALYSER	1/4" O.D.		BULKHEAD UNION
N5	OIL DRAIN	1/2" O.D.		BULKHEAD UNION
N7	COOLING WATER INLET	1/4" O.D.		BULKHEAD UNION
N11	WATER DRAIN	1/4" O.D.		BULKHEAD UNION
N12	NITROGEN INLET	1/6" O.D.		BULKHEAD UNION
PROJ. TITLE				PROJECT DWG. No.
SID. TITLE	TYPICAL FLASH POINT SAMPLE CONDITIONING SYSTEM WITH REFRIGERATION	0	A. W.	STANDARD DWG. No.
		REV.	DWN.	CK'D.
			APR.	DWG C-4- SH 2 OF 2

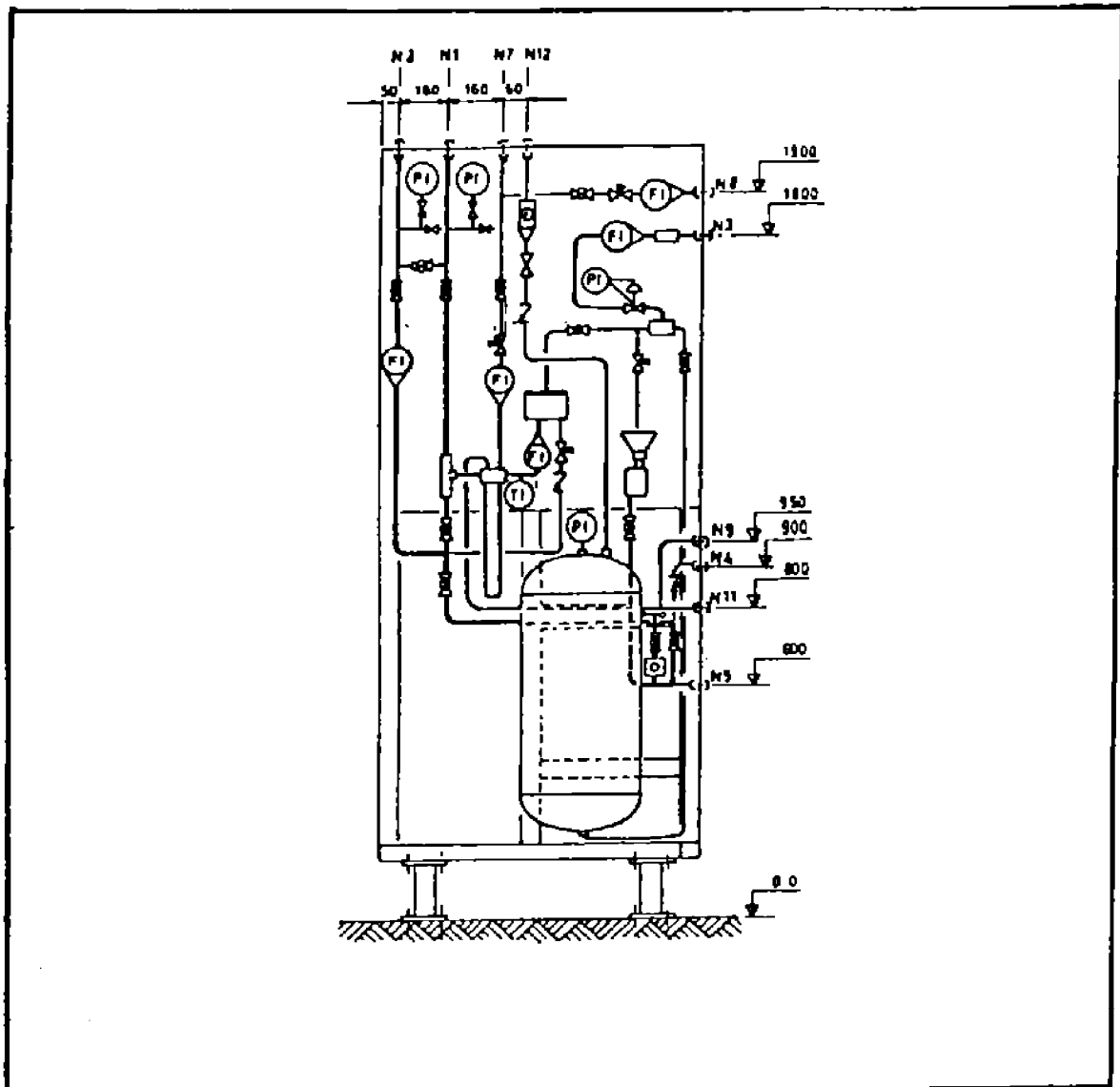


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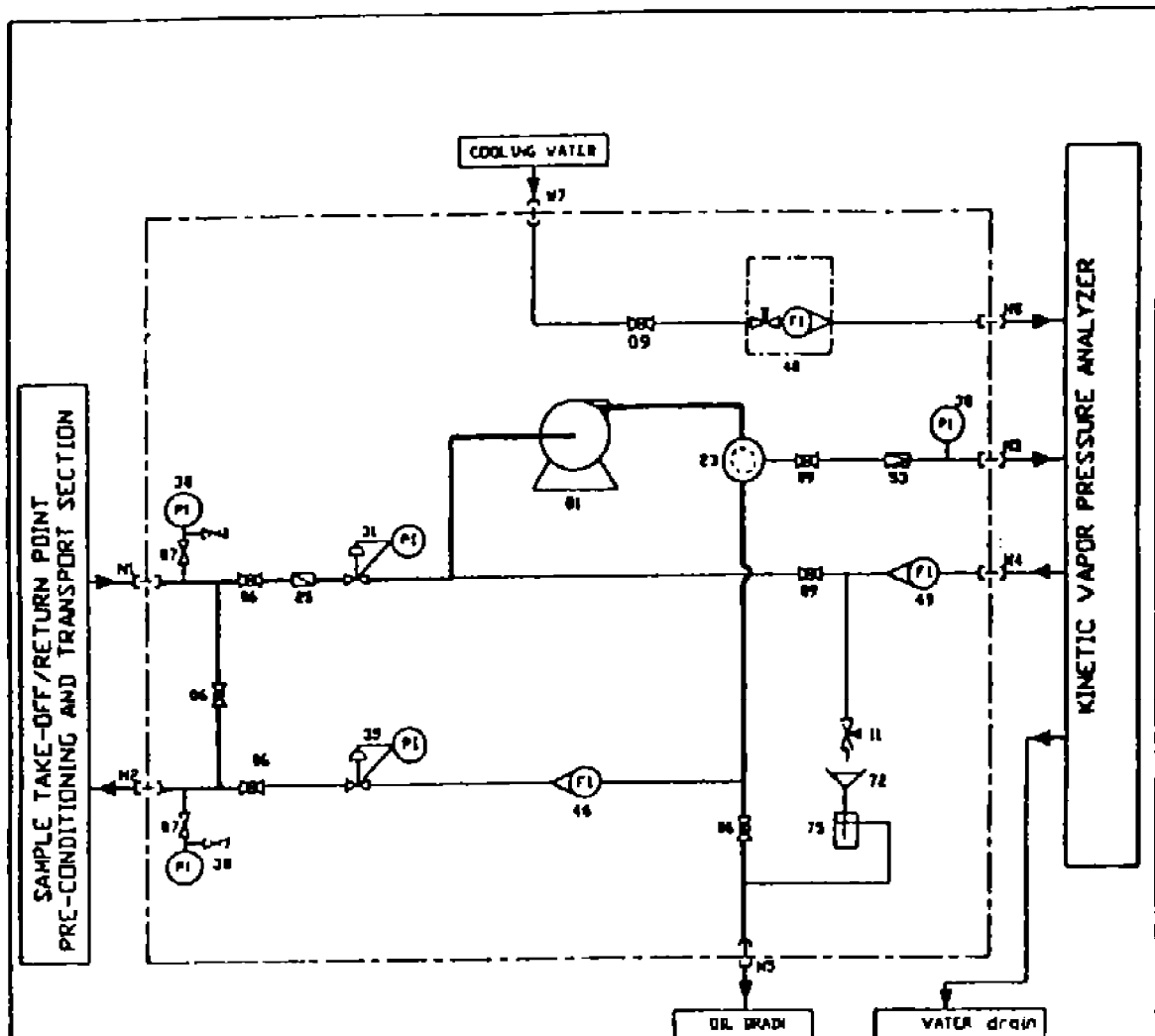
1. FOR DESCRIPTION OF NUMBERED ITEMS SEE APPENDIX C
2. DIMENSIONS AND LAY-OUT ARE TYPICAL.
3. ALL DIMENSIONS IN MILLIMETERS, UNLESS OTHERWISE STATED.
4. ALL CONNECTIONS SHALL BE BY MEANS OF BULK HEAD UNION COMPRESSION FITTINGS
5. N1, N7 AND N50 CONNECTIONS SHALL BE 1/2". ALL OTHER CONNECTIONS SHALL BE 1/4"

PROJ TITLE						PROJECT DVG NO.
STD. TITLE	TYPICAL FOUR POINT SAMPLE CONDITIONING SYSTEM	1				STANDARD DVG NO.
		REV	DWN	CK'D	APR	DWG C-5 SH 1 OF 1





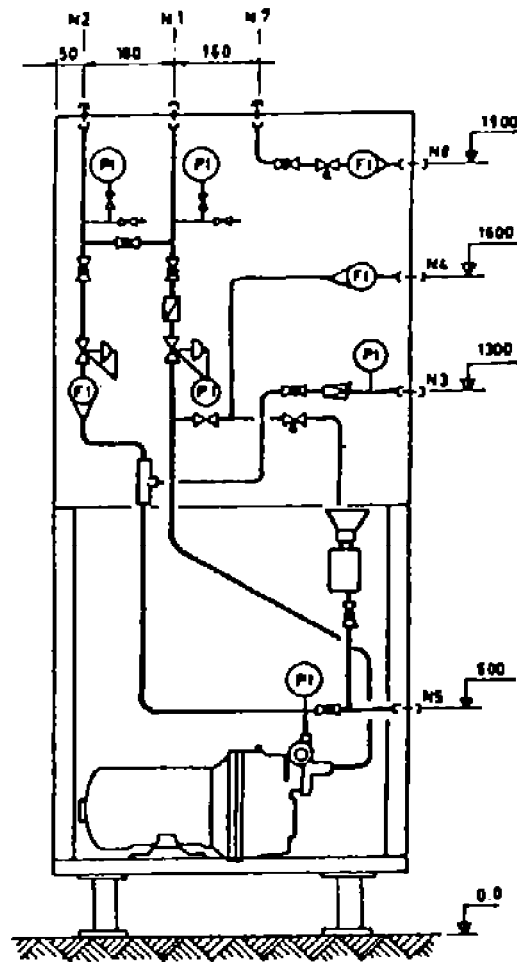
ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATERIAL	COMPRESSION TYPE	
N1	SAMPLE FASTLOOP INLET	1/2" OD		BULKHEAD UNION	
N2	SAMPLE FASTLOOP OUTLET	1/2" OD		BULKHEAD UNION	
N3	SAMPLE TO ANALYZER	1/4" OD		BULKHEAD UNION	
N4	SAMPLE RETURN FROM ANALYZER	1/4" OD		BULKHEAD UNION	
N5	OIL DRAIN	1/2" OD		BULKHEAD UNION	
N7	COOLING WATER INLET	1/2" OD		BULKHEAD UNION	
N8	COOLING WATER TO ANALYZER	1/4" OD		BULKHEAD UNION	
N9	COOLING WATER RETURN FROM ANALYZER	1/4" OD		BULKHEAD UNION	
N11	WATER DRAIN	1/2" OD		BULKHEAD UNION	
N12	NITROGEN INLET	1/4" OD		BULKHEAD UNION	
PROJ TITLE					PROJECT DWG. No.
STD. TITLE	TYPICAL CLOUD POINT SAMPLE CONDITIONING SYSTEM	0	A. P.		STANDARD DWG. No.
		REV.	DWN.	CK'D	APR.
					ENC C-6 SU 2 OF 2



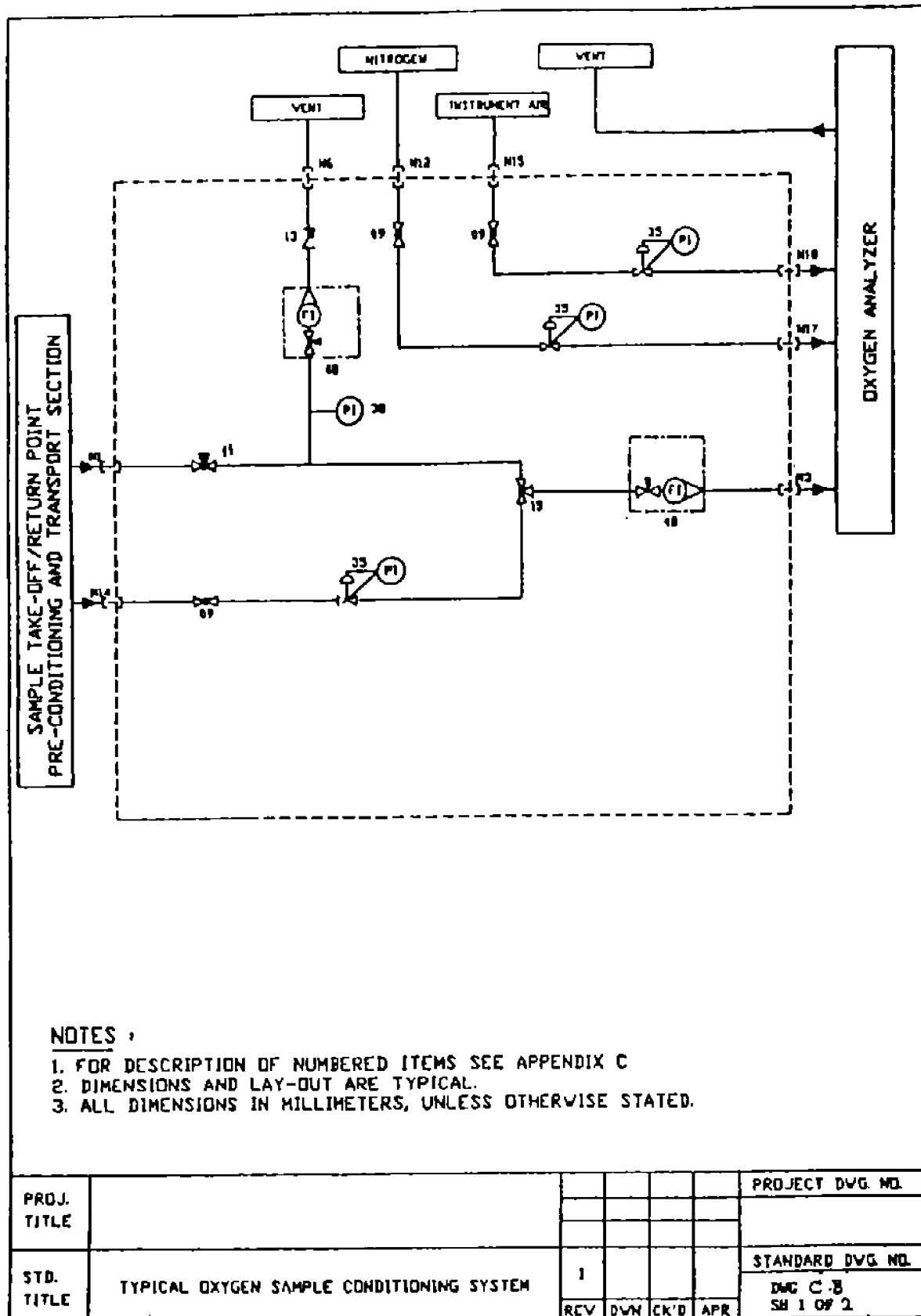
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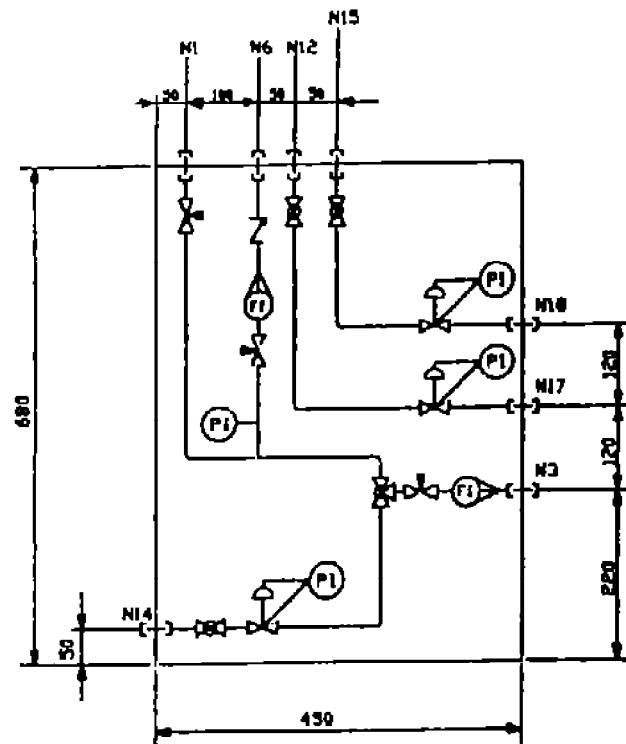
1. FOR DESCRIPTION OF NUMBERED ITEMS SEE APPENDIX C
2. DIMENSIONS AND LAY-OUT ARE TYPICAL.
3. ALL DIMENSIONS IN MILLIMETERS, UNLESS OTHERWISE STATED.

PROJ. TITLE						PROJECT DVG. NO.
STD. TITLE	TYPICAL KINETIC VAPOR PRESSURE SAMPLE CONDITIONING SYSTEM	1				STANDARD DVG. NO.
		REV	DVN	CK'D	APR	DWG C-7 SH 1 OF 2



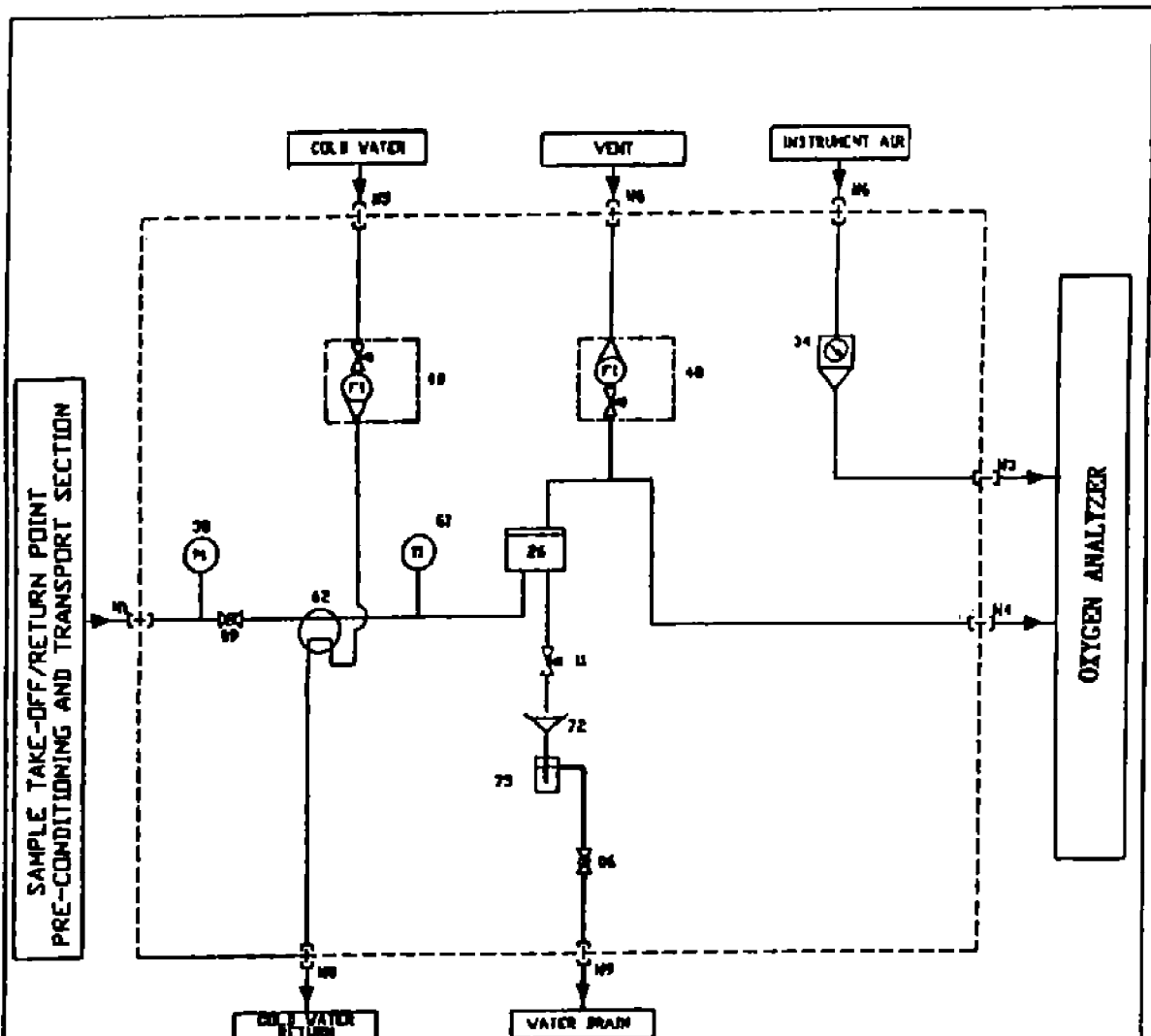
ITEM	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE FASTLOOP INLET	1/2" OD		BULKHEAD UNION
N2	SAMPLE FASTLOOP OUTLET	3/2" OD		BULKHEAD UNION
N3	SAMPLE TO ANALYZER	1/4" OD		BULKHEAD UNION
N4	SAMPLE RETURN FROM ANALYZER	1/4" OD		BULKHEAD UNION
N5	OIL DRAIN	1/2" OD		BULKHEAD UNION
N7	COOLING WATER INLET	1/4" OD		BULKHEAD UNION
N8	COOLING WATER TO ANALYZER	1/4" OD		BULKHEAD UNION
PROJ TITLE				PROJECT DWG. No.
STD TITLE	TYPICAL KINETIC VAPOR PRESSURE SAMPLE CONDITIONING SYSTEM	0	A. P.	STANDARD DWG. No.
		REV	DWN CK'D APR.	DMC C-7 SM2 OP2





ITEM.	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE INLET	1/4"O.D.		BULKHEAD UNION
N3	SAMPLE TO ANALYZER	1/4"O.D.		BULKHEAD UNION
N6	SAMPLE TO VENT	1/4"O.D.		BULKHEAD UNION
N12	NITROGEN INLET	1/4"O.D.		BULKHEAD UNION
N14	CALIBRATION SAMPLE INLET	1/4"O.D.		BULKHEAD UNION
N15	INSTRUMENT AIR INLET	1/4"O.D.		BULKHEAD UNION
N17	CALIBRATION GAS TO ANALYZER	1/4"O.D.		BULKHEAD UNION
PROJ. TITLE				PROJECT DVG. NO.
STD. TITLE	TYPICAL OXYGEN SAMPLE CONDITIONING SYSTEM	1		STANDARD DVG. NO.
		REV	BY/H	CK'D APR

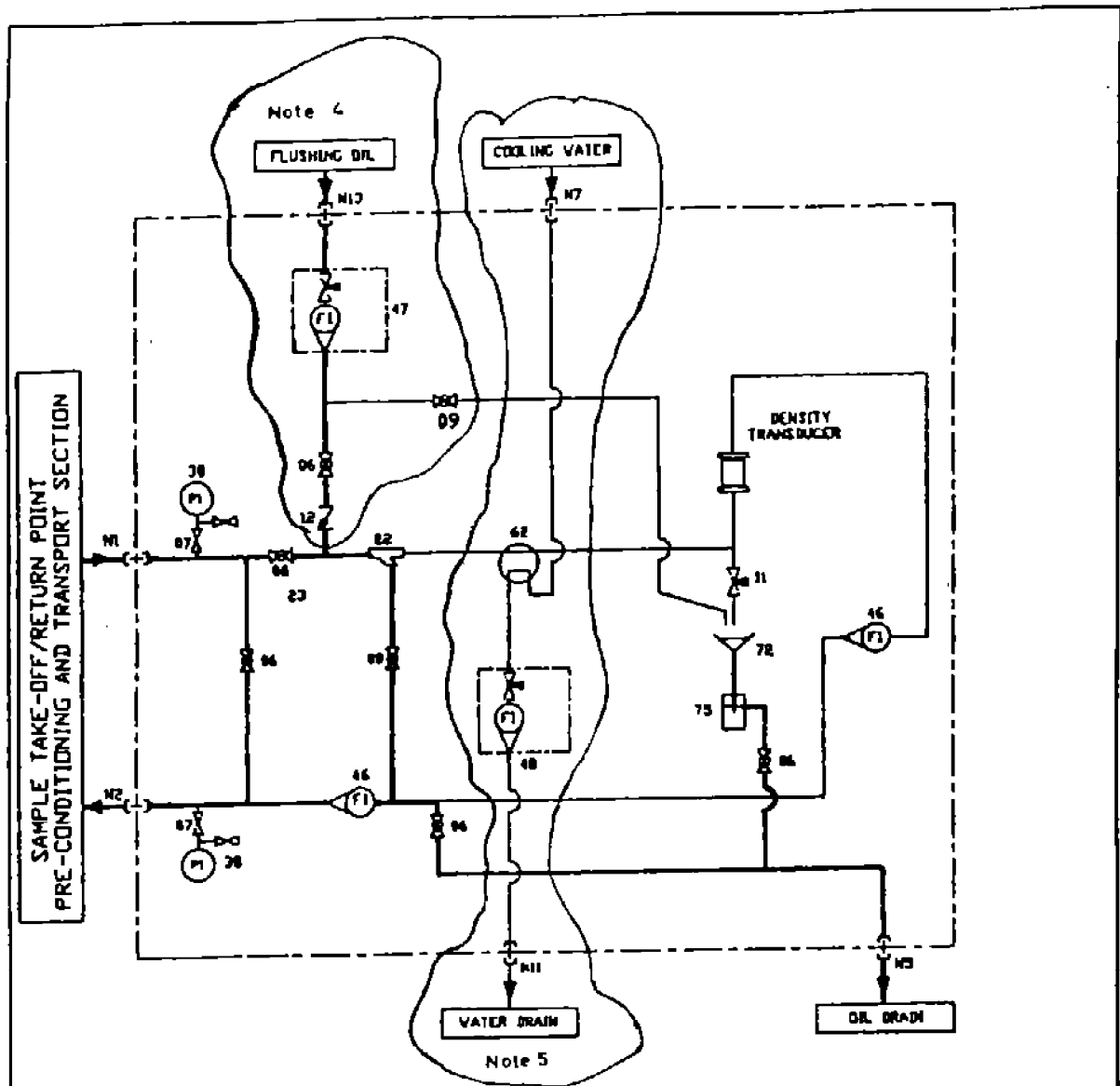
DWG C-8
SH 2 OF 2



NOTES :

1. ALL CONNECTIONS SHALL BE 1/4" BULKHEAD UNION COMPRESSION FITTINGS EXCEPT N9
2. N5 AND N8 ARE COOLING MEDIUM FROM AND TO REFRIGERATOR.

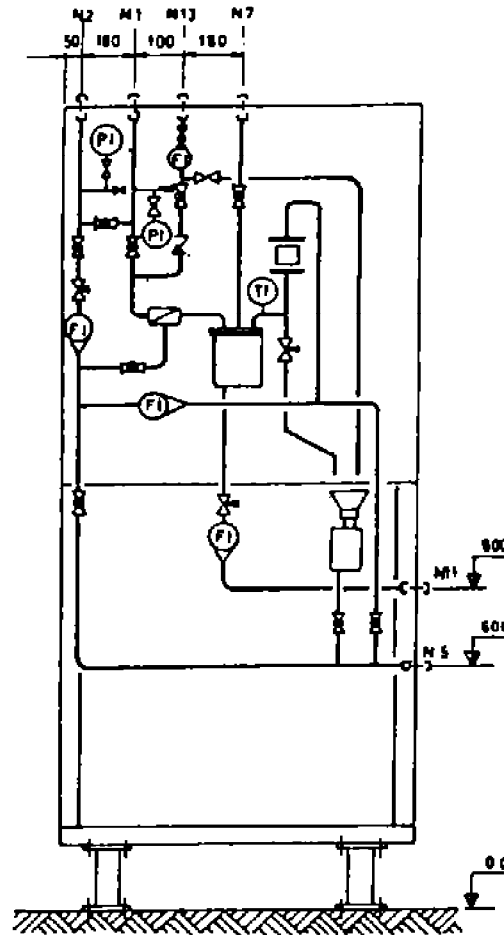
PROJ. TITLE					PROJECT DWG. NO.
STD. TITLE	TYPICAL N2 PURITY ANALYZER SAMPLE CONDITIONING SYSTEM	1			STANDARD DWG. NO.
		REV	DVN	CK'D	APR
					DWG C-9 SH 1 OF 1



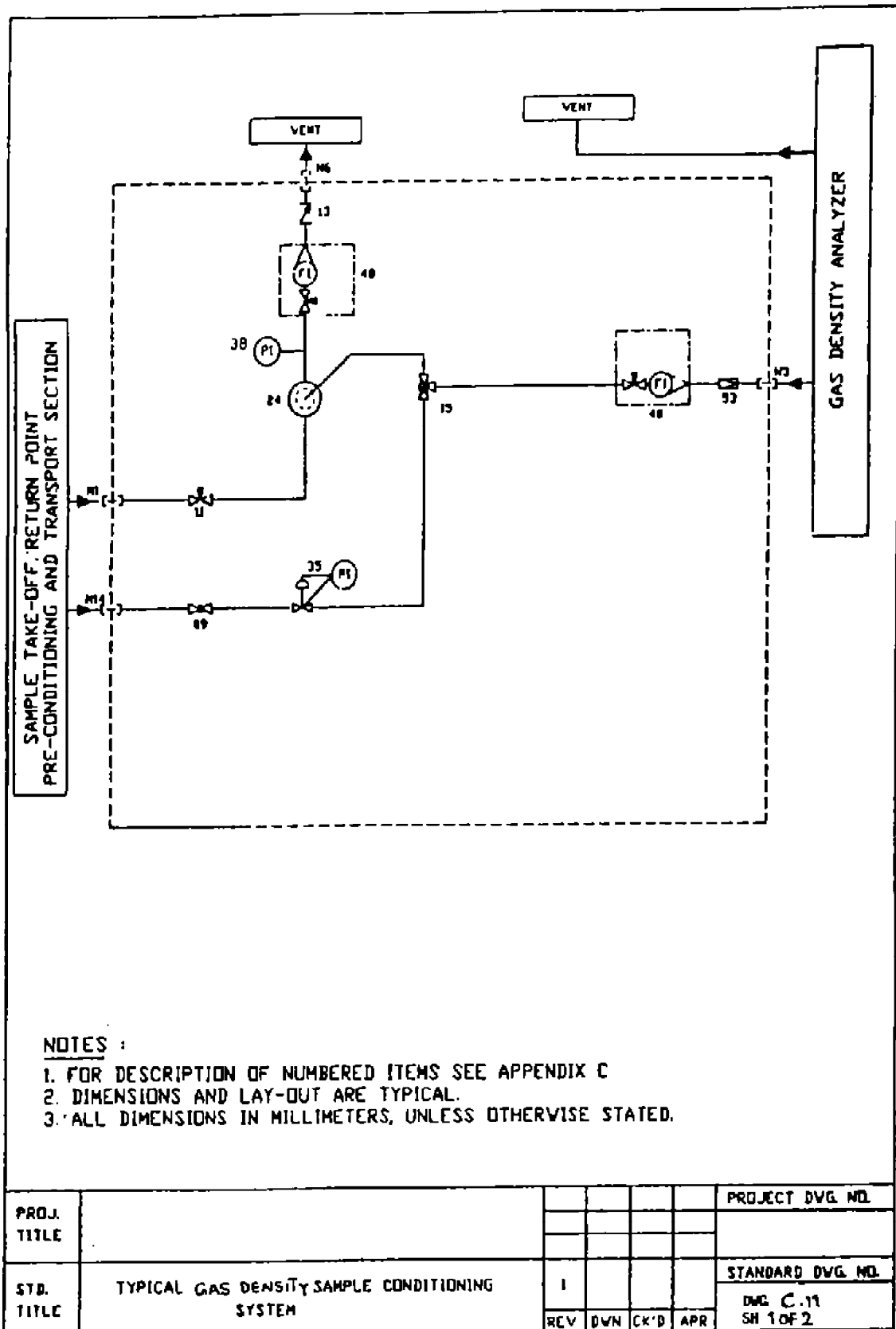
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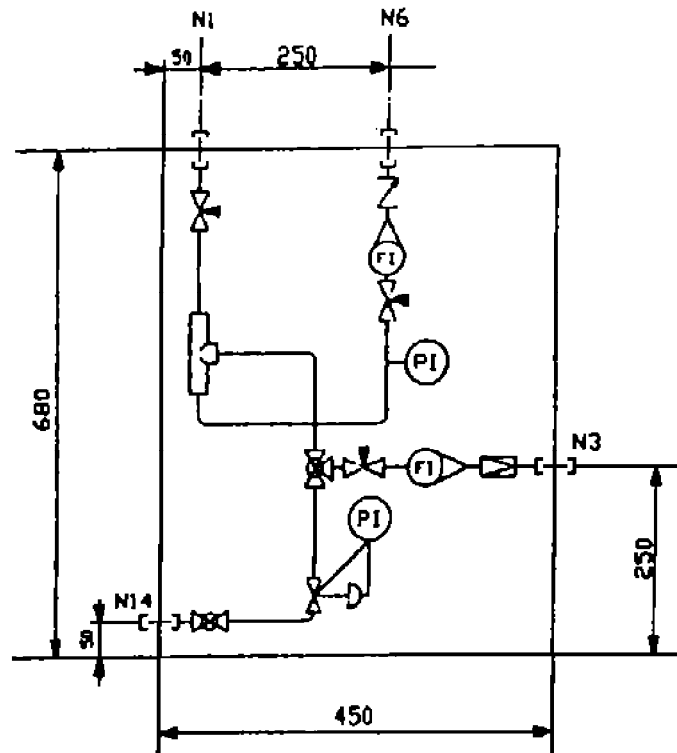
1. FOR DESCRIPTION OF NUMBERED ITEMS SEE APPENDIX C
2. DIMENSIONS AND LAY-OUT ARE TYPICAL.
3. ALL DIMENSIONS IN MILLIMETERS, UNLESS OTHERWISE STATED.
4. FLUSHING WILL BE DELETED IF NOT SPECIFIED
5. COOLING WILL BE DELETED IF NOT SPECIFIED

PROJ. TITLE						PROJECT DWG. NO.
TITLE	TYPICAL LIQUID DENSITY SAMPLE CONDITIONING SYSTEM WITH COOLING, FLUSHING OR BOTH	1				STANDARD DWG. NO.
		REV	DWN	CK'D	APR	DWG C. 10 SH 1 OF 2

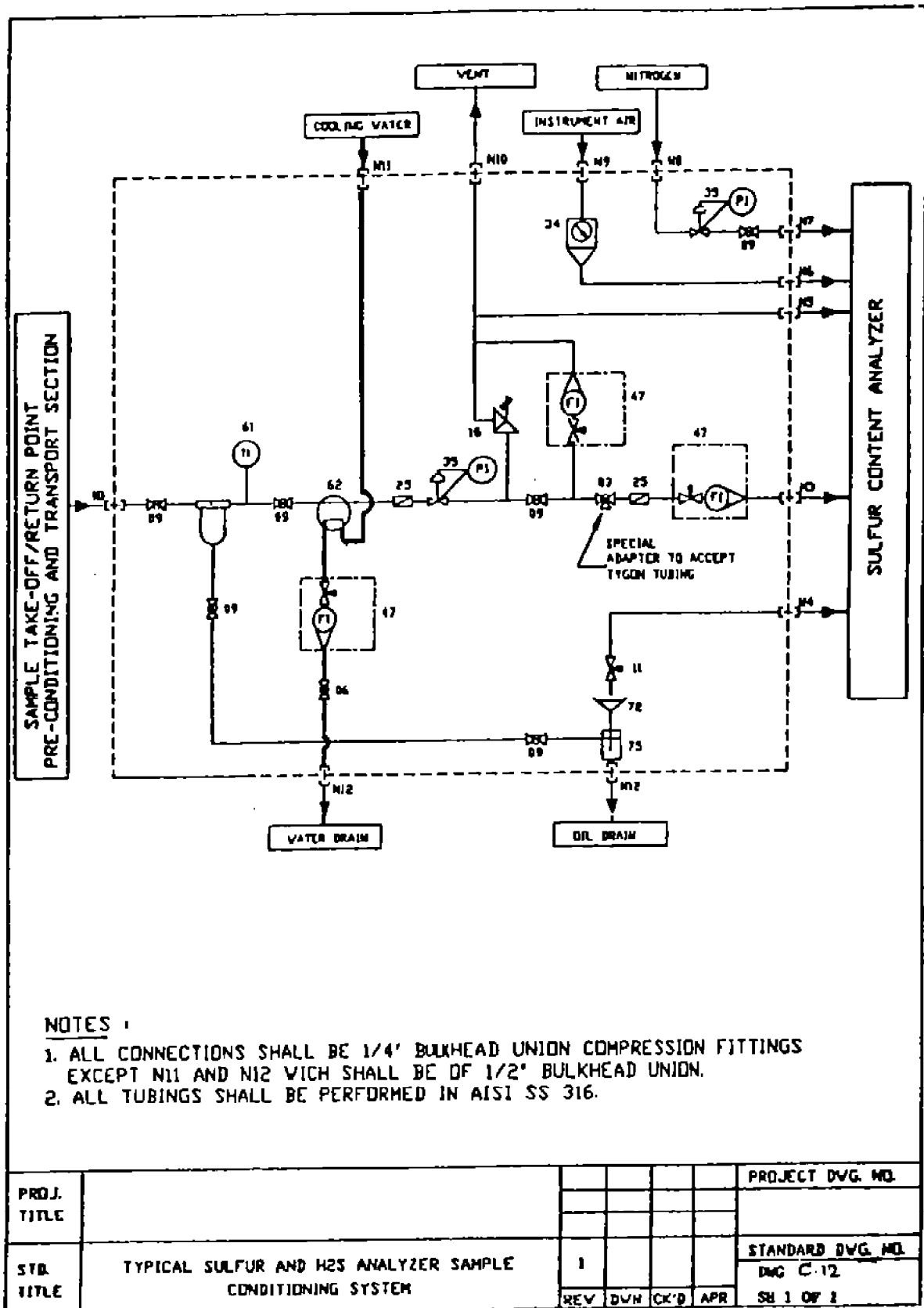


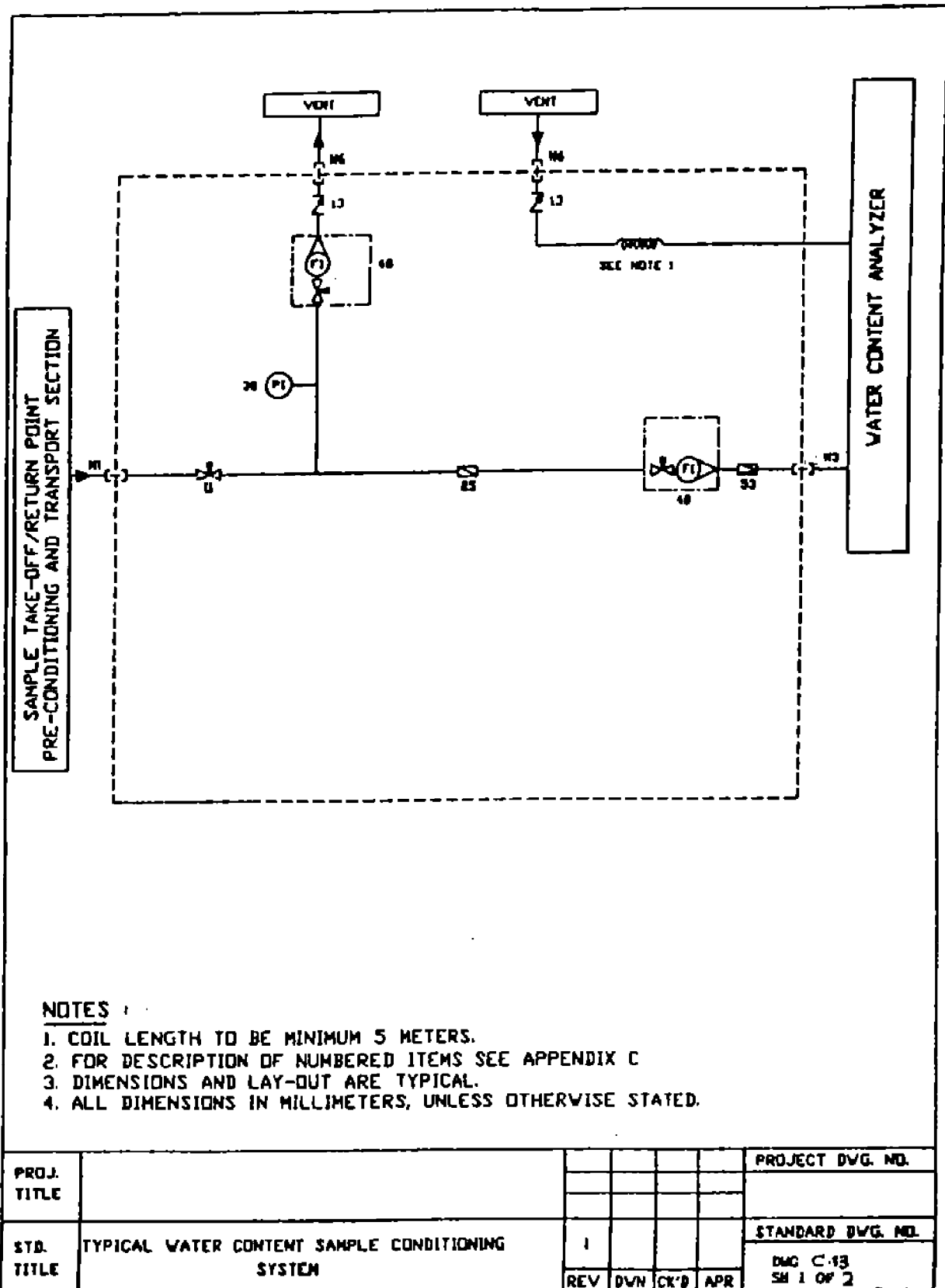
ITEM.	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE FASTLOOP INLET	1/2" O.D.		BULKHEAD UNION
N2	SAMPLE FASTLOOP OUTLET	1/2" O.D.		BULKHEAD UNION
N3	OIL DRAIN	1/2" O.D.		BULKHEAD UNION
N7	COOLING WATER INLET	1/2" O.D.		BULKHEAD UNION
N11	WATER DRAIN	1/2" O.D.		BULKHEAD UNION
N3	FLUSHING OIL INLET	1/2" O.D.		BULKHEAD UNION
PROJ				PROJECT DWG. No.
TITLE				
SID.	TYPICAL LIQUID DENSITY SAMPLE CONDITIONING SYSTEM WITH COOLING FLUSHING OR BOTH			STANDARD DWG. No.
TITLE		REV.	DWN.	CK'D.
			APR.	
				DWG C-10 SH 2 OF 2

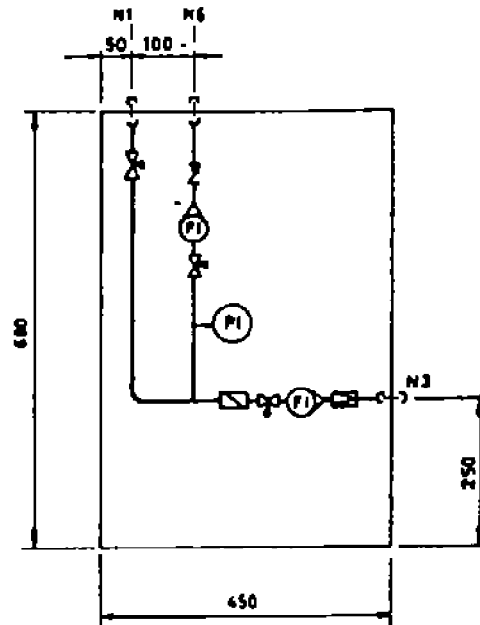




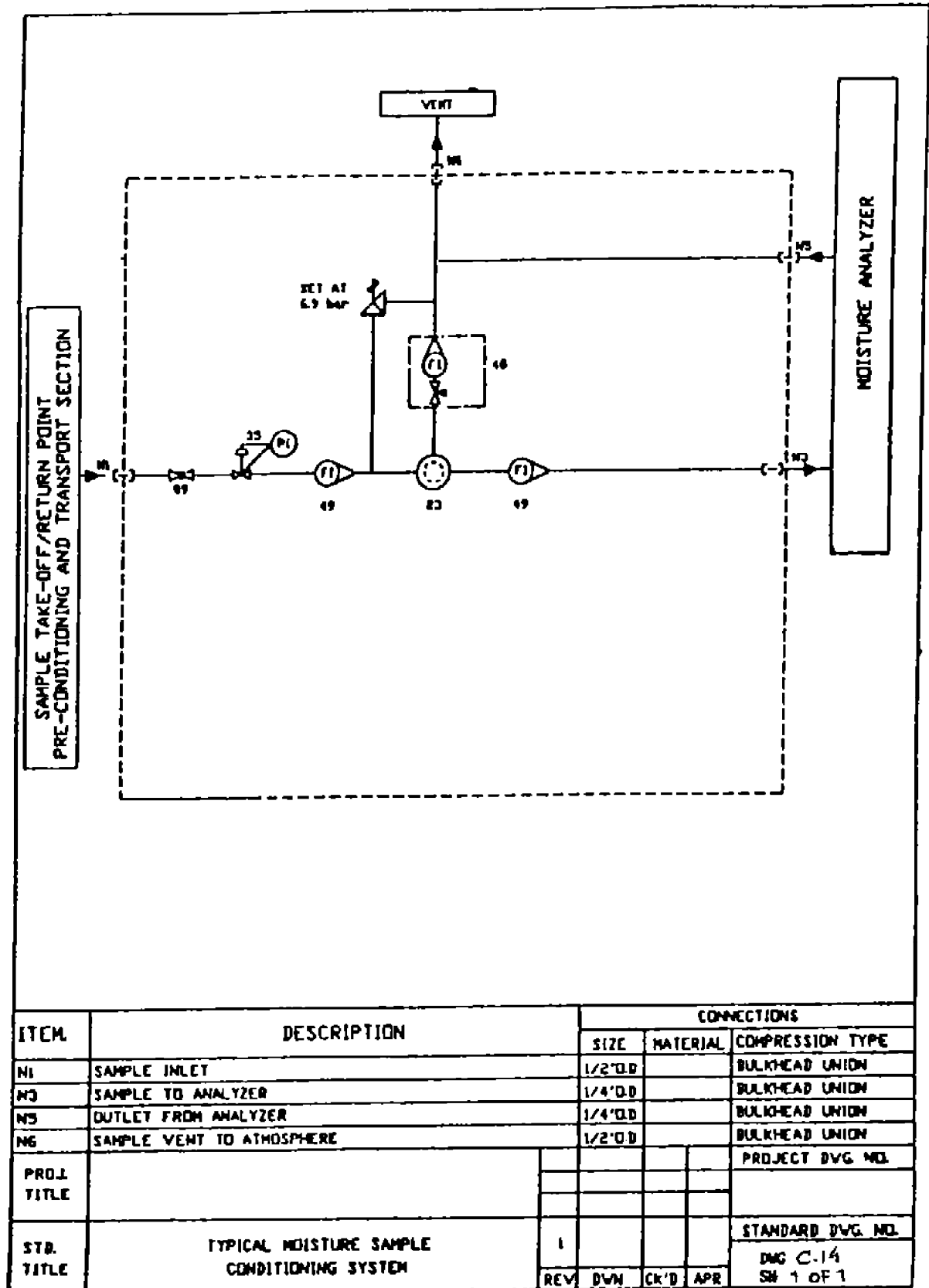
ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATERIAL	COMPRESSION TYPE	
N1	SAMPLE INLET	1/4"O.D		BULKHEAD UNION	
N3	SAMPLE TO ANALYZER	1/4"O.D		BULKHEAD UNION	
N6	SAMPLE TO VENT	1/4"O.D		BULKHEAD UNION	
N14	CALIBRATION GAS INLET	1/4"O.D		BULKHEAD UNION	
PROJ TITLE					PROJECT DVG. NO.
STD. TITLE	TYPICAL GAS DENSITY SAMPLE CONDITIONING SYSTEM	1			STANDARD DVG. NO.
		REV	DNV	CK'D	APR
		DVG C.11 SB 2 OF 2			

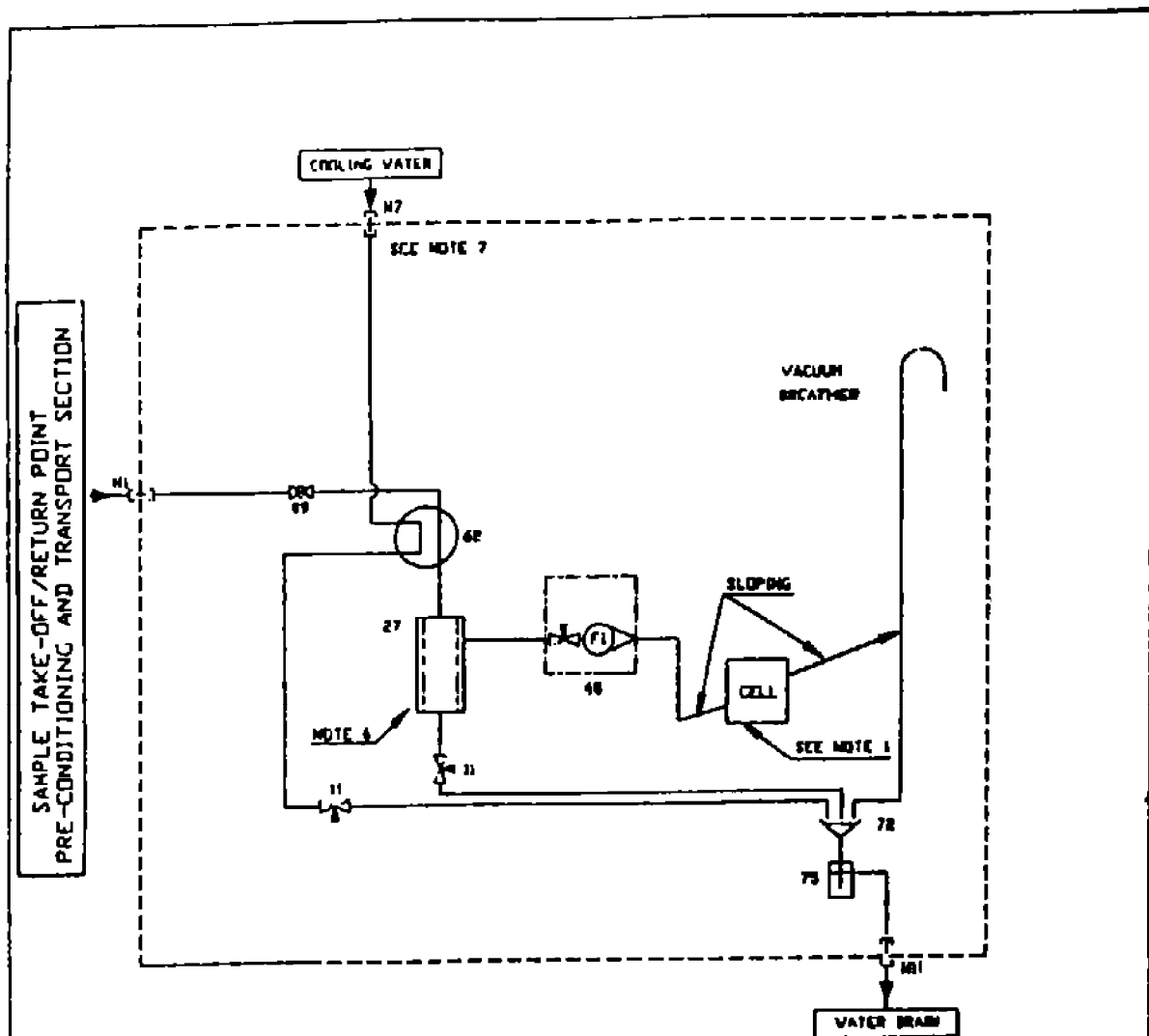






ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATERIAL	COMPRESSION TYPE	
N1	SAMPLE INLET	1/4" O.D.		BULKHEAD UNION	
N3	SAMPLE TO ANALYZER	1/4" O.D.		BULKHEAD UNION	
N6	SAMPLE TO VENT	1/4" O.D.		BULKHEAD UNION	
PROJ				PROJECT DWG. No.	
TITLE					
STD.				STANDARD QWES No.	
TITLE	TYPICAL WATER CONTENT SAMPLE CONDITIONING SYSTEM	0	A. R.	DWG C-13	
		REV	DWN	CR'D	APR.
					SH 2 OF 2

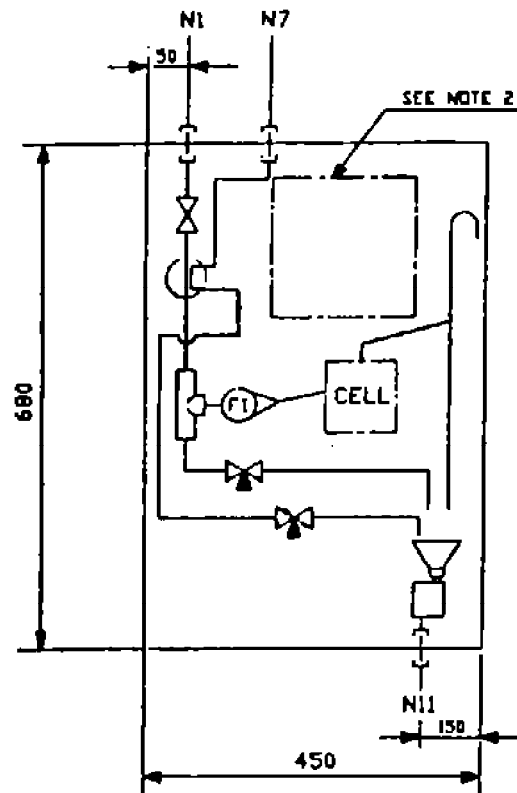




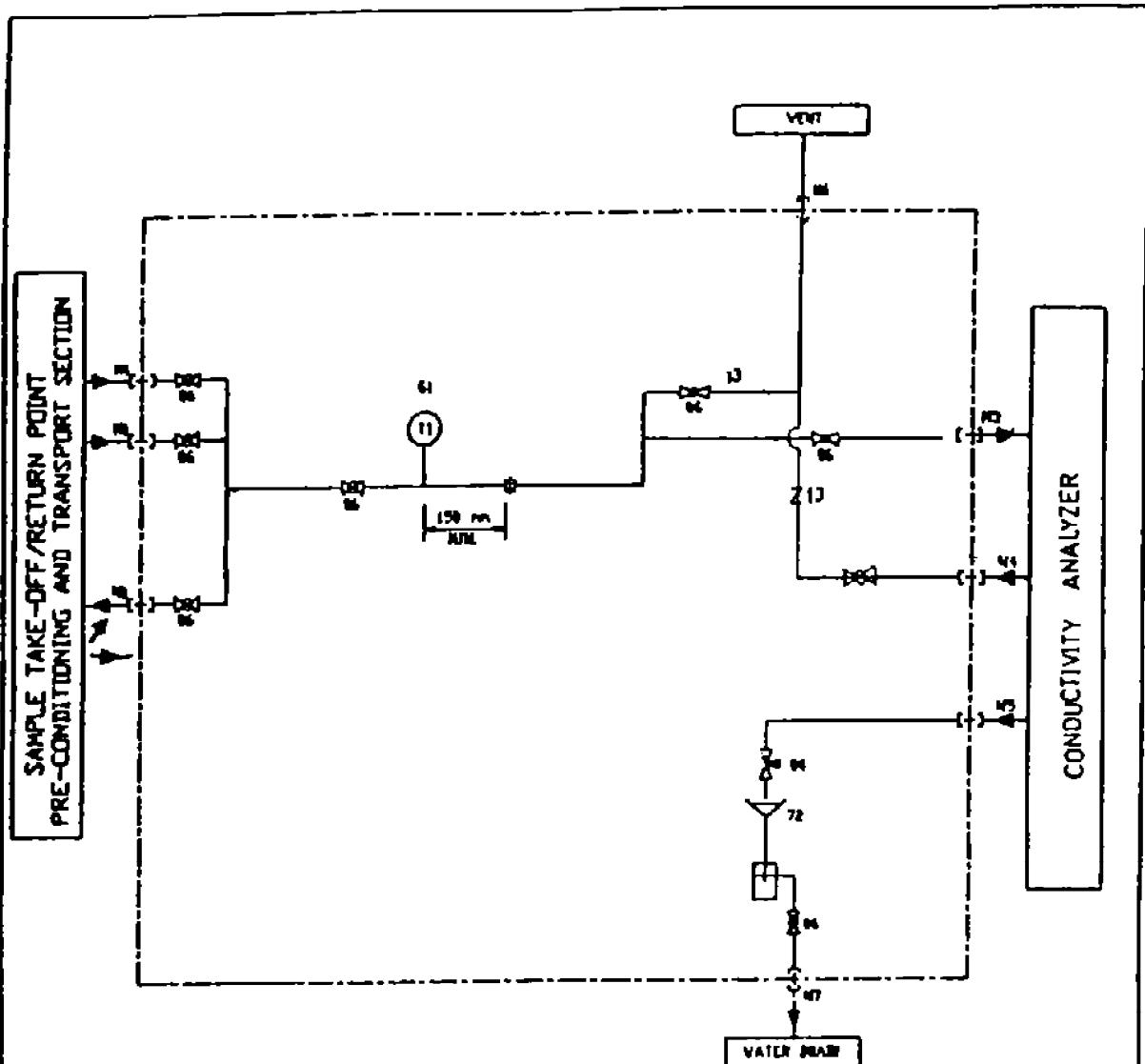
NOTES

1. FOR TYPE MEASURING CELL SEE REQUISITION AND RELEVANT DRAWING OF ANALYZER.
FLOW CELL TO BE INSTALLED BELOW INLET AND OUTLET LINE LEVEL TO MAINTAIN LIQUID IN CELL.
FLOW CELL TO BE INSTALLED SO THAT GAS SCAVENGING IS ASSURED.
2. SPEC FOR TRANSMITTER AND LOCAL INDICATOR, IF REQUIRED, SHALL BE PROVIDED
3. FOR DESCRIPTION OF NUMBERED ITEMS SEE APPENDIX C
4. DIMENSIONS AND LAY-OUT ARE TYPICAL.
5. ALL DIMENSIONS IN MILLIMETERS, UNLESS OTHERWISE STATED.
6. DELETED IF SPECIFIED WITHOUT FILTER / COALESCER.
7. COOLING WATER SHALL BE ADDED, IF REQUIRED.

PROJ. TITLE						PROJECT DWG. NO.
STD. TITLE	TYPICAL PH CONDUCTIVITY SAMPLE CONDITIONING SYSTEM	1				STANDARD DWG. NO.
		REV	DWN	CK'D	APR	DWG C-15 SH 1 OF 2



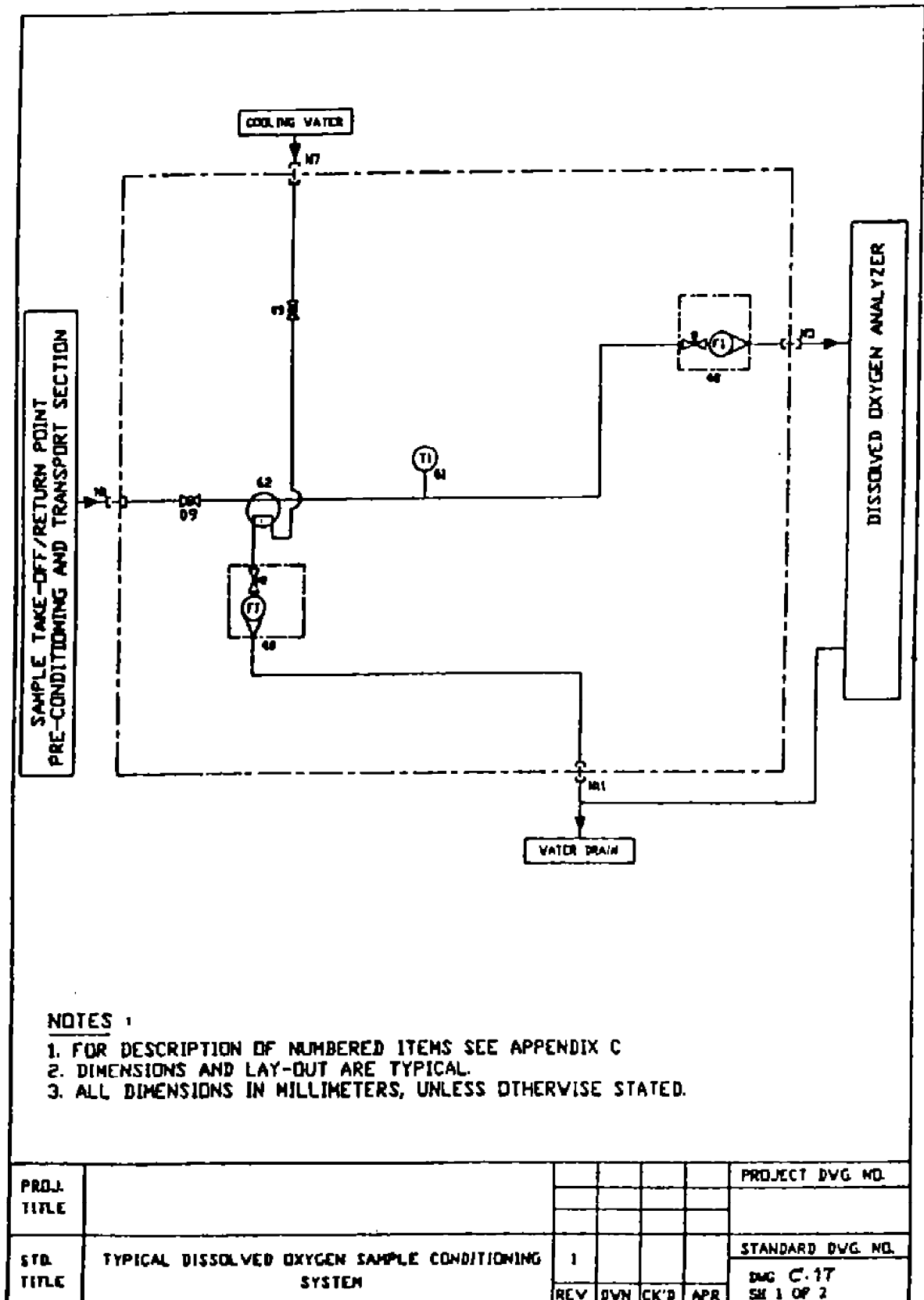
ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATERIAL	COMPRESSION TYPE	
N1	SAMPLE INLET	1/4" O.D.		BULKHEAD UNION	
N11	WATER DRAIN	1/2" O.D.		BULKHEAD UNION	
N7	COOLING WATER INLET	1/4" O.D.		BULKHEAD UNION	
PROJ. TITLE				PROJECT DVG. NO.	
STD. TITLE	TYPICAL PH CONDUCTIVITY SAMPLE CONDITIONING SYSTEM	1			STANDARD DVG. NO.
		REV	BYN	CK'D	APR

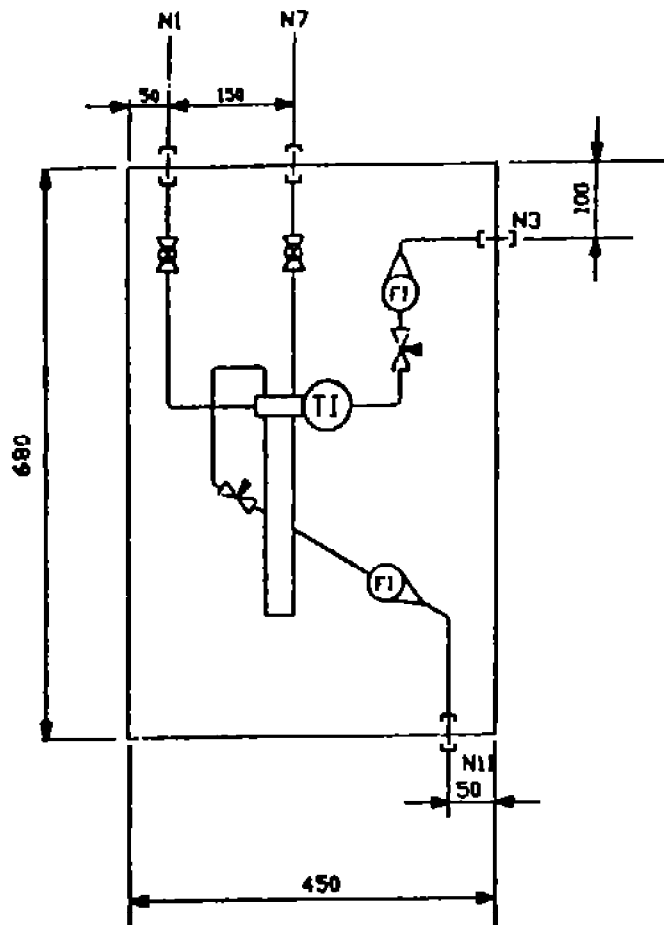


NOTES :

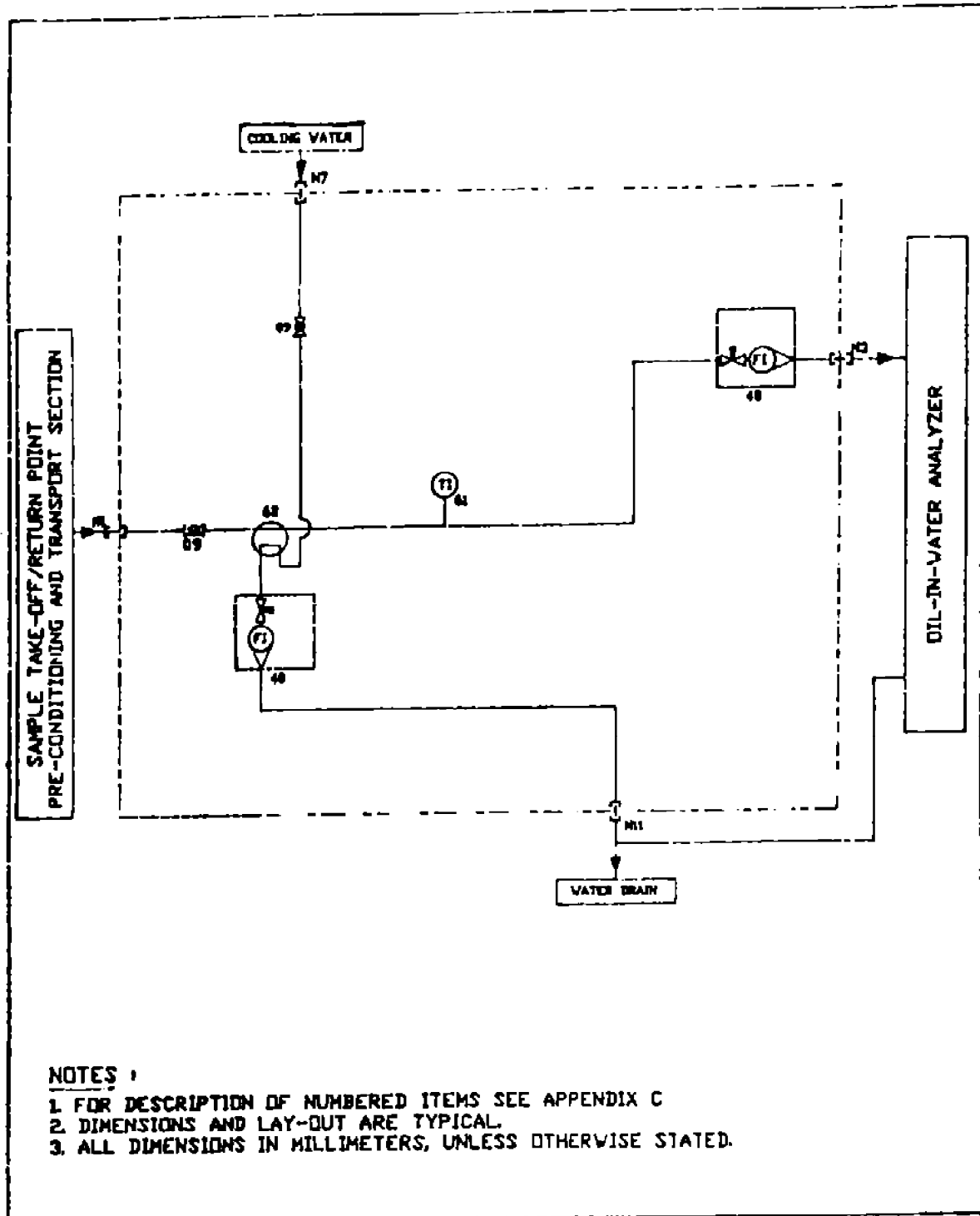
1. ALL TUBING AND FITTINGS SHALL BE 316 SS.
2. ALL CONNECTIONS SHALL BE TERMINATED WITH BULKHEAD UNION COMPRESSION TYPE FITTINGS.
3. ALL THREADED CONNECTIONS SHALL BE SEALED WITH TEFLON TAPE.
4. ALL CONNECTIONS SHALL BE 1/2"
5. ALL DIMENSIONS IN MILLIMETERS, UNLESS OTHERWISE STATED.

PROJ. TITLE					PROJECT DVG. NO.
STD. TITLE	TYPICAL STEAM PURITY SAMPLE CONDITIONING SYSTEM	1			STANDARD DVG. NO.
		REV	DWN	CK'D	APR
					DWG C-16 SH 1 OF 1

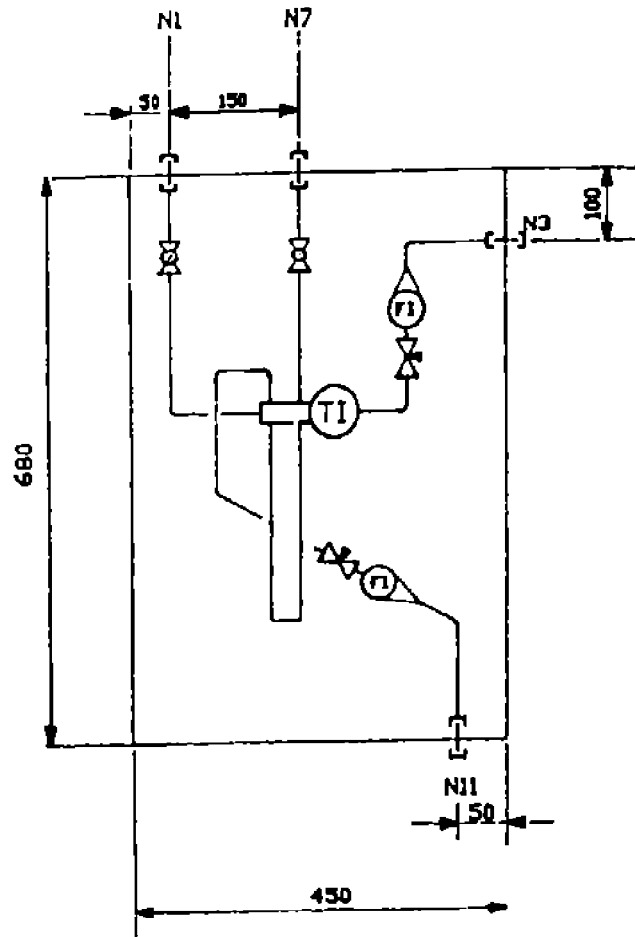




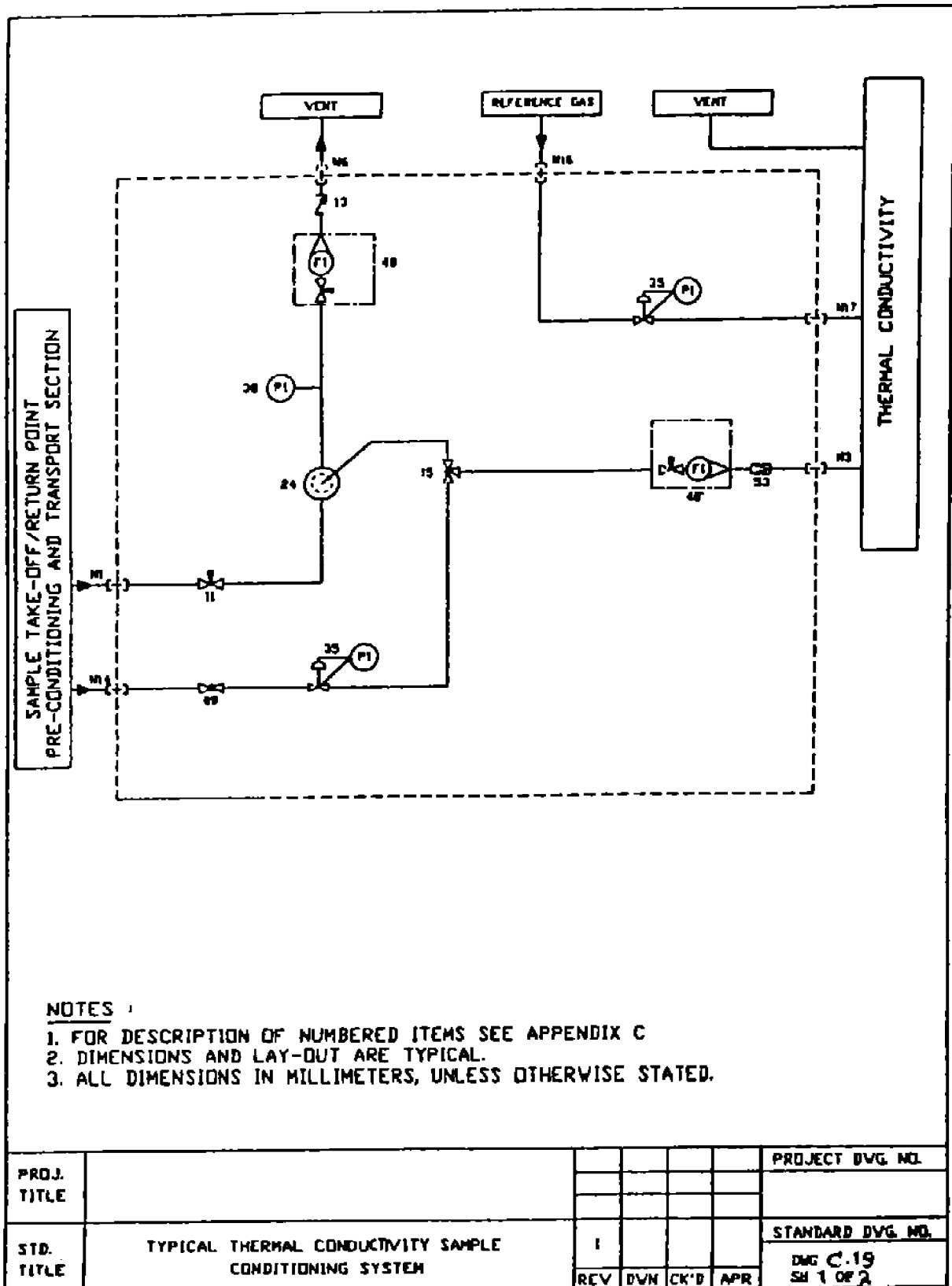
ITEM	DESCRIPTION	CONNECTIONS		
		SIZE	MATERIAL	COMPRESSION TYPE
N1	SAMPLE INLET	1/4"OD		BULKHEAD UNION
N3	SAMPLE TO ANALYZER	1/4"OD		BULKHEAD UNION
N7	COOLING WATER INLET	1/4"OD		BULKHEAD UNION
N11	WATER DRAIN	1/4"OD		BULKHEAD UNION
PROJ. TITLE				PROJECT DVG. NO.
STR. TITLE	TYPICAL DISSOLVED OXYGEN SAMPLE CONDITIONING SYSTEM	0		STANDARD DVG. NO.
		REV	DWH	CK'D APR
				DWG C-17 SH 2 OF 2

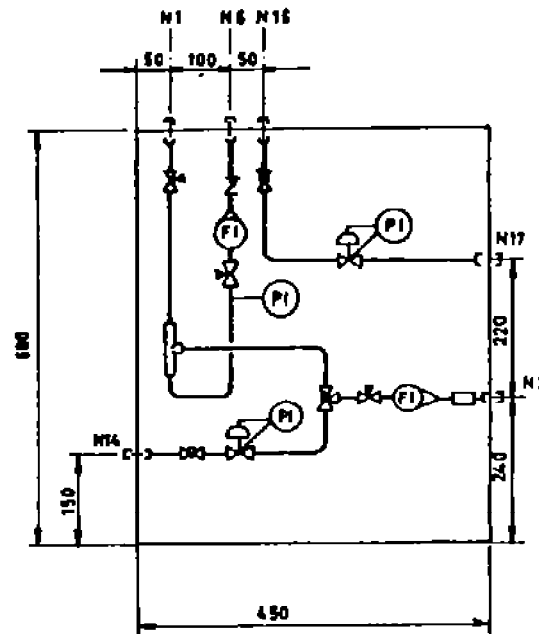


PROJ TITLE					PROJECT DWG. NO.
STD TITLE	TYPICAL OIL-IN-WATER SAMPLE CONDITIONING SYSTEM	1			STANDARD DWG. NO.
		REV	DWN	CK'D	APR
					DWG C-18 SH 1 OF 2

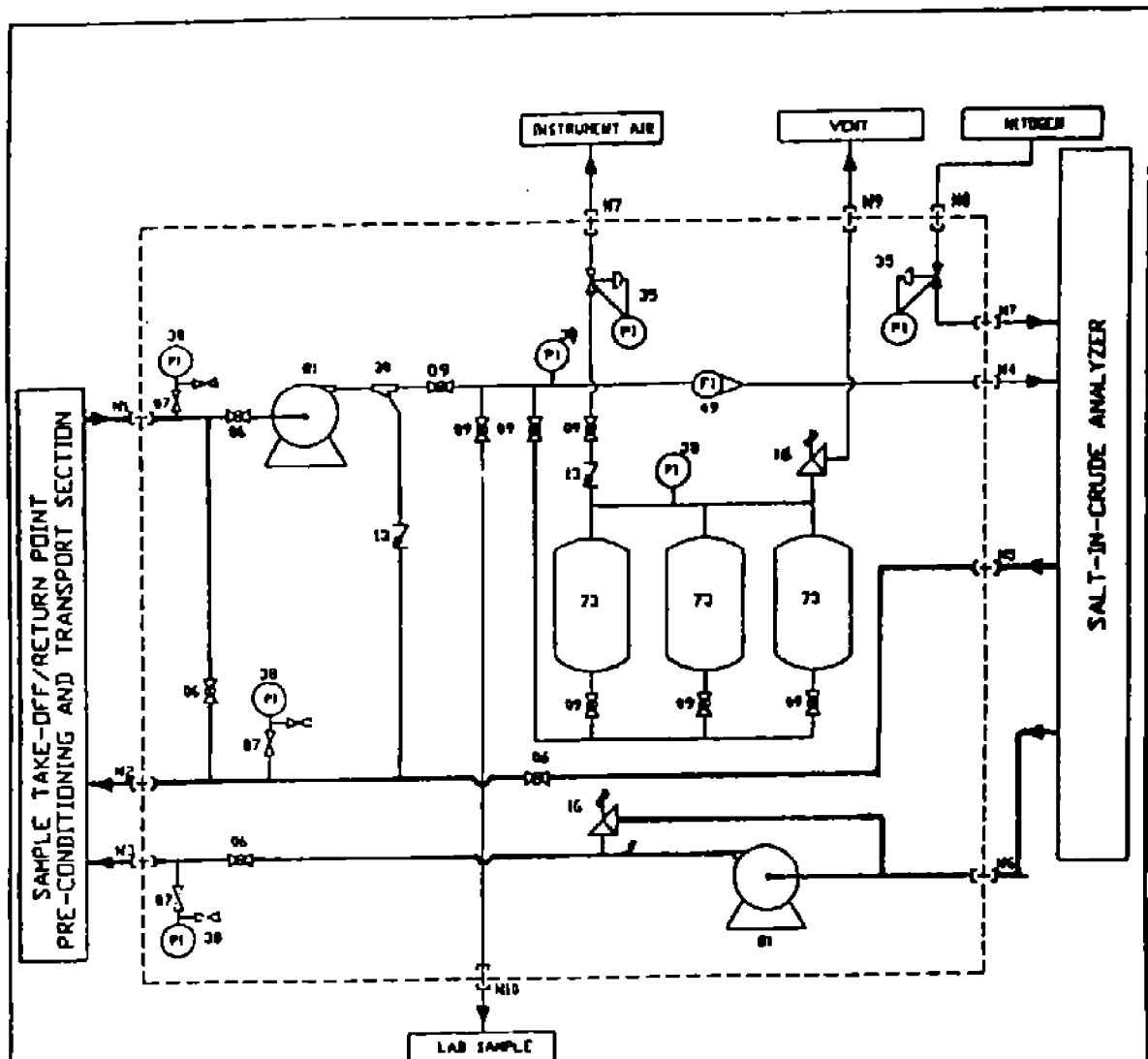


ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATERIAL	COMPRESSION TYPE	
N1	SAMPLE INLET	1/4"O.D.		BULKHEAD UNION	
N3	SAMPLE TO ANALYZER	1/4"O.D.		BULKHEAD UNION	
N7	COOLING WATER INLET	1/4"O.D.		BULKHEAD UNION	
N11	WATER DRAIN	1/4"O.D.		BULKHEAD UNION	
PROJ. TITLE					PROJECT DVG. NO.
STD. TITLE	TYPICAL OIL-IN-WATER SAMPLE CONDITIONING SYSTEM	1			STANDARD DVG. NO.
		REV	DVN	CK'D	APR
		DWG C-18 BN 2 OF 2			





ITEM.	DESCRIPTION	CONNECTIONS			
		SIZE	MATREIAL	COMPRESSION TYPE	
N1	SAMPLE INLET	1/4" OD		BULKHEAD UNION	
N3	SAMPLE TO ANALYZER	1/4" OD		BULKHEAD UNION	
N6	SAMPLE TO VENT	1/4" OD		BULKHEAD UNION	
N14	CALIBRATION SAMPLE INLET	1/4" OD		BULKHEAD UNION	
N16	REFERENCE GAS INLET	1/4" OD		BULKHEAD UNION	
N17	REFERENCE GAS TO ANALYZER	1/4" OD		BULKHEAD UNION	
PROJ. TITLE					PROJECT DWG. No.
STD. TITLE	TYPICAL THERMAL CONDUCTIVITY SAMPLE CONDITIONING SYSTEM	0	A. R.		STANDARD DWG. No.
		REV.	DWN	CHK'D	APR.



NOTES

1. ALL TUBING & FITTINGS IN CONTACT WITH FLUIDS MUST BE OF STAINLESS STEEL
2. CALIBRATION VESSELS SHALL BE REMOVABLE FOR LAB FILLING OR ANALYSIS.
3. N1=CRUDE IN, N2=CRUDE OUT, N3= SPENT SAMPLE RETURN, SHALL BE OF 3/4" PIPING
4. N4= CRUDE TO ANALYZER, N5= CRUDE OUT OF ANALYZER, N7= NITROGEN TO ANALYZER, SHALL BE 1/4" S.S. COMPRESSION BULKHEAD UNIONS.
5. N8=NITROGEN IN, N9= INSTRUMENT AIR IN, SHALL BE 1/4" S.S. COMPRESSION BULKHEAD UNIONS.
6. N10=VENT, SHALL BE 1/4" BULKHEAD UNION, COMPRESSION FITTING.

PROJ. TITLE					PROJECT DVG. NO.
STD. TITLE	TYPICAL SALT-IN-CRUDE SAMPLE CONDITIONING SYSTEM	1			STANDARD DVG. NO.
		REV	DWN	CK'D	APR
					DWG C-20 SH 1 OF 1

APPENDIX C

**PART II: COMPONENTS OF THE SAMPLE CONDITIONING SYSTEM USED
IN THE TYPICAL DRAWINGS (C1 TO C20)**

ITEM	DESCRIPTION	SIZE
01	Bleed orifice	½" Flanged
02	Three-way valve	½" NPT (F)
03	Three-way valve	¼" NPT (F)
04	Needle valve	½" NPT (F)
05	T-filter	½" Connections
06	Ball valve	½" NPT (F)
07	Isolate/vent valve	½" NPT (F)
08	Globe valve	½" NPT (F)
09	Ball valve	¼" NPT (F)
11	Needle valve	¼" NPT (F)
12	Check valve	½" NPT (F)
13	Check valve	¼" NPT (F)
14	Pneumatic actuator	
15	Ball valve 3-way	¼" NPT (F)
16	Relief valve	½" NPT (F)
17	Relief valve	¼" NPT (F)
22	Strainer	½" NPT
23	By-pass filter	½" NPT
24	By-pass filter	¼" NPT
25	Removable filter	
26	Filter/coalescer	¼" NPT
27	Filter/coalescer	¼" NPT
29	In-line filter	¼" NPT
30	Strainer	
31	Pressure regulator	½" NPT
32	Back-pressure regulator	½" NPT
34	Filter/regulator	¼" NPT
35	Pressure regulator	¼" NPT
36	Back-pressure regulator	¼" NPT
38	Pressure gage	½" NPT
39	Pressure gage	¼" NPT
46	Flow meter	½" NPT
47	Flow meter (with needle valve)	½" NPT
48	Flow meter (with needle valve)	¼" NPT
49	Flow meter	¼" NPT
52	Flow controller	¼" NPT
53	Excess flow valve
61	Temperature gage
62	Cooler or heater	½" NPT
71	Sample valve (change over)
72	Funnel
73	Calibration vessel
74	Calibration vessel with diaphragm seal	½" NPT
75	Syphon	½" NPT
76	Sight glass
81	Sample pump
86	Gas drier	¼" NPT
89	Bubbler/manostat	

PART 2**GENERAL-CONSTRUCTION STANDARD**

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1. SCOPE

This part of Standard covers the installation and construction specification to be followed in construction work for analyzer systems.

The specification is prepared for two alternatives; the first alternative is for the case, when the analyzer house is provided as prefabricated enclosure with the analyzers pre-installed at factory or by System Integrator and the second alternative is for masonry analyzer house to be constructed by the contractor.

This part covers the following instrumentation works for the analyzers:

- Construction
- Installation
- Testing

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Contractor.

API (AMERICAN PETROLEUM INSTITUTE)

RP-550 "Manual on Installation of Refinery Instrument and Control System" - Part II, Process Stream Analyzers, Section 1, Analyzers

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)

Bulletin 70 "National Electrical Code" (NEC)

NFC 496 "Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations" (1982)

ISA (INSTRUMENT SOCIETY OF AMERICA)

S 12.4 "Practice for Instrument Purging for Reduction of Hazardous area Classification"

3. ANALYZER HOUSE INSTALLATION (PREFABRICATED TYPE)

In applications, where the analyzer house is shipped to the job site completely assembled and ready for installation, the following work items shall be performed by the contractor.

3.1 The contractor shall construct a concrete pad to erect the analyzer house on this pad. The concrete pad shall serve as the floor for the enclosure.

3.2 The concrete pad floor shall be resistant to chemicals and easy to clean and suitably sloped for proper drainage. Electrical power cables and instrument signal cables shall enter and leave the analyzer house via separate openings in the floor, at one of the corners.

3.3 A drain and vent system shall also be provided for sample disposal. Outlet openings flush with the floor shall be provided in the floor to allow escape of gases and vapors heavier than air.

3.4 Adequate lighting around the analyzer house with minimum general lighting level of 30 foot-candles shall be provided by area lighting system.

3.5 The house is force ventilated type. The contractor shall install the air intake stack with the pertinent rain hood. The air shall be provided from a non hazardous area free of corrosive, flammable, or toxic gases. A positive pressure of 2.5 mm of water shall be maintained in the analyzer house to prevent flammable and toxic gases from entering the house through it's exterior walls.

3.6 The following general considerations shall be fulfilled by the contractor:

- 1) The system must meet all safety requirements as specified in project documents.
- 2) The system and its components must be accessible for removal and service.

4. ANALYZER HOUSE CONSTRUCTION (MASONRY TYPE)

4.1 Building

4.1.1 The analyzer house shall be totally closed masonry housing.

4.1.2 Electrical power and instrument signal cables shall enter and leave the analyzer house via separate openings in the floor, at one of the corners.

4.1.3 Lighting system shall be provided (internally and externally), as specified in project drawings.

4.1.4 The type of protection for the lighting facilities and electrical utilities shall be suitable for class 1, group C/D, Division II areas (as a minimum) according to NEC or according to equivalent European area classification.

4.1.5 Power distribution panel shall be provided consisting of individual isolation circuit for each item (analyzer HVAC, lighting, etc.), complete with automatic circuit breaker and signaling lamps.

4.1.6 Utility headers and connections shall be provided and mounted on both sides of the walls, as necessary, according to the project drawings.

4.1.7 Floors shall be of material which can be easily cleaned from oil spills and which is acid resistance when there is a chance of spillage of chemicals used in the analyzers or in their cleaning/repair.

4.1.8 An acid resistant sink shall be provided complete with domestic water supply with sufficient space between sink and tap.

4.1.9 The analyzer house drain shall be connected to the oil contaminated drain system via a corrosion resistant drain pipe and a water lock.

4.1.10 Drain pits for sample disposal shall be provided at the ends of the longest walls outside the analyzer house.

4.1.11 When the housing floor is concrete, it shall have a slope of 1 in 30 toward the drain located outside the housing.

4.1.12 When the housing floor is a raised open grid, it shall be in easily removable sections. The area under the house shall be concrete as per item 4.6.11.

4.1.13 Free-standing analyzers shall be mounted on rigid floor support members.

4.1.14 If there is any difference in level between floor and ground, a concrete ramp shall be provided leading up to each entrance of the house enabling wheeled equipment to enter the building conveniently. Access shall be for the full width of each entrance.

4.1.15 Equipment such as gas cylinders, standard sample vessels and parts of the sample treating system which are located outside the housing shall be provided with a roof or shelter. Suitable racking shall be supplied for gas cylinders.

4.1.16 The house walls and roof shall be thermally insulated to conform suitably to the environmental conditions.

4.1.17 Flow restriction shall be provided in all lines carrying hazardous materials into the house from bottles, such as; hydrogen carrier gas for process gas chromatographs.

4.1.18 Auxiliary instruments, such as; programmers, control units, peak holding equipment, service recorders and signal converters shall be installed in small open panels, racks or on the walls in the analyzer house. These instruments shall be mounted at normal working level. These instruments shall not be mounted underneath any type of equipment handling or using any kind of liquids.

4.1.19 A small work bench shall be placed in the analyzer house, as well as storage shelves or cupboards with wire mesh doors for tools and cleaning materials. Fully enclosed cupboards in which hazardous vapors or gases may accumulate must not be used.

4.1.20 Overhead trunking shall be provided in the analyzer house for all interconnecting cables. Such a trunking shall also be used for the signal cables to the terminal boxes that interface the under ground cables run to the control rooms.

4.1.21 Gas cylinders shall be connected in pairs by means of a double needle valve for continuous and uninterrupted operation of the analyzer. The cylinders shall be equipped with automatic cylinder change-over facility with proper alarms.

4.2 Artificial Ventilation System

4.2.1 Air intake system

4.2.1.1 The air intake shall be through a stack constructed with a rainhood, as shown in project drawing. The air shall be drawn from a non-hazardous area.

4.2.1.2 The construction of the intake duct and the diameter of the stack shall be in a manner to limit the air velocity inside the ducting to a maximum of 8 m/sec. For desert areas a sand blockage filter shall be provided in the stack.

4.2.2 Air inlet and outlet openings

4.2.2.1 The ventilation air shall enter the analyzer house via ducts and leave the house via openings equipped with weight-loaded louvers.

4.2.2.2 Outlet openings shall be at floor and ceiling levels to allow escape of gases and vapors both heavier and lighter than air. The outlets shall be flush with floor and ceiling to prevent accumulation and trapping of gases and vapors.

4.3 HVAC

An air conditioning system shall be provided according to the project documents to maintain temperature at specified value.

5. SAMPLING SYSTEM AND ANALYZER INSTALLATION

5.1 Sampling System Piping

5.1.1 Piping shall be erected by the contractor to be run from the first block valve off the process header to the sample conditioning system on the exterior wall of the analyzer house.

5.1.2 The piping shall include all vents, drains and recirculating piping block valves to the process header.

5.1.3 Analyzer accessories, i.e.; sample conditioning system, sample recovery system, calibration and carrier gas bottles shall be installed on the external wall of the analyzer house according to the project drawings. The installation work shall also include piping for any service required for calibration, carrier gas, extra air supply and so on.

5.1.4 The physical or chemical properties of material to be measured shall not be changed in the sampling system.

5.1.5 Samples, where low concentrations of physically or chemically active components are being measured (e.g. moisture or H₂S at levels below 100 ppm), require special consideration. Particular care shall be taken in design and the choice of materials used for sampling system construction to minimize the effects of adsorption and desorption on surfaces:

- a) All internal surfaces shall be smooth and generally AISI 316 stainless steel is the preferred material, provided that; it is not chemically reactive with any component of the sample stream.
- b) Non-metallic components shall be avoided unless their chemical or physical properties are superior and are specified or agreed with the Company.
- c) Sample line length and sampling system volume shall be kept to a minimum.
- d) The temperature of the sample line and all components shall generally be kept constant and above ambient temperature by heat tracing and lagging.
- e) Velocity in the sample line shall be as high as practicable.

5.1.6 Where necessary, vapor phase samples shall be heat traced and lagged to keep the sample at a temperature which will avoid condensation.

5.1.7 The volume of liquid between the take-off point of the fast loop and the vaporizer shall be minimized (e.g. the volume of LPG increases approximately 300 times when vaporized at a pressure of 1 bara).

5.1.8 Heat tracing and lagging shall be provided as necessary, particularly to replace heat absorbed at the vaporizer.

5.1.9 Gas samples shall be pressure-reduced as close as possible to the sampling point or the fast loop to reduce time lags. Heat tracing and lagging may be necessary at the pressure reducer to replace heat and lagging may be necessary at the pressure reducer to replace lost by the Joule Thomson effect.

5.1.10 Samples from lines containing two-phase mixtures or mixtures of immiscible fluids require special consideration. Where analysis of the mixture is required, the samples shall be taken from a section of the line where the flow is turbulent. ISO 3171, while specifically relating to crude oil, offers further guidance on two phase sampling.

5.1.11 Facilities for flushing of sample lines and analyzer shall be provided in the following cases:

- a) On all streams where the sample has a viscosity greater than 500 C.S. at 38°C.
- b) Where solidification is possible.
- c) For corrosive and toxic services.

5.2 Inter-Connecting Tubing to the Analyzer

5.2.1 Interconnecting tubing between sample conditioning system and the analyzer shall be performed by the contractor through the analyzer house wall.

5.2.2 The tubing shall be performed according to the analyzer vendor recommendations and project hook-up drawings.

5.2.3 The entrance holes for tubing to the analyzer shall be suitably isolated for heat transfer and air/vapor leakage to and from the analyzer house.

5.3 Analyzer System Installation

5.3.1 Analyzer system equipment shall be installed, wired, and interconnected according to the vendor installation manual and recommendations.

5.3.2 All cabling & wirings to and from analyzer house shall be executed in accordance with IPS-C-IN-190 "Transmission Systems".

6. UTILITIES AND FACILITIES

6.1 Electricity Supply

6.1.1 The electricity supply shall be executed in accordance with the requirements of IPS-E-EL-200 "Lighting and Wiring" and IPS-C-EL-195 "Precautions in Electrical Installation in Potentially Explosive Gas Atmosphere", with details of the electrical supply subject to the requirements of electrical apparatus to be installed.

6.1.2 Test equipment, electrical tools and electrical equipment without adequate protection for Division II area shall be connected to the electricity supply via wall sockets only; the supply for which shall be automatically isolated upon ventilation failure.

6.2 Air and Water

6.2.1 Instrument air shall be supplied in accordance with the requirements of IPS-C-IN-200 "Instrument Air System".

6.2.2 Water shall be supplied in accordance with the requirements of IPS-E-CE-360 "Building Piping (Hot and Cold Water)", entering the house at a different position of the electricity supply.

6.3 Sample Disposal System

6.3.1 Vent and drain system

6.3.1.1 Vent and drain systems shall be installed in the conditioning area against the outside wall(s) of the analyzer house and shall be adequately supported at intervals of 1 meter maximally.

6.3.1.2 The vent and drain systems shall be executed by; carbon steel/all-welded construction, stainless steel/AISI 316/all-welded construction, or rigid PVC plastic/cemented construction, as specified in the project documents.

6.3.1.3 The vent header pipe size shall be ¾" and drain header size shall be 3", unless otherwise specified in the project documents. The interconnecting piping shall be executed by ½" pipe, unless otherwise specified in project drawings.

6.3.1.4 Suitable goose-neck liquid seals shall be installed for all connections to drain header which do not have isolating valve.

6.3.1.5 Separate drain headers shall be provided for cooling water and condensate return system.

6.3.2 Gas disposal to flare

6.3.2.1 The contractor shall provide all piping necessary to connect the vent system to the nearest flare header, as indicated on project drawings.

6.3.3 Liquid disposal to recovery system

6.3.3.1 The contractor shall execute all necessary piping for hydrocarbon liquids disposal to one of the following systems, as required in the project;

- Plant hydrocarbon recovery system, or
- drain pit for hydrocarbon products.

6.3.4 Liquid disposal to waste water system

6.3.4.1 The contractor shall execute all necessary piping to waste water system, as required in the project technical documents.

6.4 Additional Utilities

6.4.1 The following additional utility pipings shall also be executed, as appropriate, according to the project technical documents:

- Tool air,
- nitrogen Pippings,
- hydrogen gas (as carrying gas),
- LP steam,
- MP steam,
- condensate supply and return lines,
- cooling water.

6.4.2 All utility pipings shall have main shut-off valves, grouped together in the vicinity of (with minimum distance of 2 meters away) the analyzer house. The shut-of valves shall be clearly identified by means of suitable Red Colored Labels.

6.5 Electrical System

6.5.1 Safeguarding system electrical panel (for power disconnection and interlocking) shall be installed by the contractor, feeding all general purpose electrical apparatus, such as wall sockets.

6.5.2 Flammable gas detectors in the analyzer house shall be installed by the contractor according to the project drawings and vendor recommendations.

6.5.3 All interlocking and safety apparatus shall be installed by the contractor complete ready for operation.

6.6 Winterizing

For installation in cold and temperate climates, adequate winterizing shall be installed by the contractor to prevent solidification of samples in the sampling systems.

7. PURGING FOR HAZARDOUS AREA REDUCTION

7.1 The contractor shall provide the air purging piping to all instruments requiring purged air in their enclosures.

7.2 The instrument enclosures shall be provided with one of the following types of purging, required by the specific analyzer type, as specified in project documents:

- Type X purge which reduces the classification within an enclosure from Division I to non-hazardous.
- Type Y purge which reduces the classification within an enclosure from Division I to Division II.
- Type Z purge which reduces the classification within an enclosure from Division II to non-hazardous.

7.3 Power shall be turned on for a purged instrument enclosure only after a four-volume purge (Ten volume for enclosures exceeding 10 cubic feet) has been completed and a minimum internal pressure of 5 mm of water column has been established.

7.4 The installation contractor shall ensure that the requirements of ISA-S 12.4 as explained in Article 7.2, "Practice for Instrument Purging for Reduction of Hazardous Area Classification ", and NFPA-496" Purged and Pressurized Enclosures for Electrical Equipment", are satisfied for hazardous area reductions.

7.5 Instrument quality air shall be used on all hazardous area reduction classifications.

8. DUCTING

8.1 The installation contractor shall execute all ducting works for air inlet and outlet to and from the analyzer house.

8.2 The ducting material shall be of non-corrosive metal plate, such as; hot-dipped galvanized steel.

8.3 Ducts shall not pass through Division I areas. Inlet ducts shall be air-tight. Ducts shall not pass through Division II areas unless there is no other choice. In the latter case, the length of the duct in the Division II shall be kept to minimum.

8.4 A filter shall be installed in the ducting in a manner to be easily accessible for cleaning or replacement. The area of the filter shall be sized, to require cleaning/replacement not more than once a week, under maximum dust conditions expected.

8.5 Ducting openings to atmosphere shall be protected from rain and particulate matters and neither wind velocity nor wind direction shall have any affect on the analyzer house ventilation via ductwork. Hoods and wire mesh screens shall be installed where required.

9. MARKING FOR IDENTIFICATION AND INFORMATION

9.1 Analyzer House Nameplate

9.1.1 Sufficient quantity of the nameplates, as mentioned herein, shall be provided by the contractor screwed on all doors of the analyzer house. The nameplates shall be of laminar white plastic provided by the installation contractor.

9.1.2 The first nameplate on the analyzer house doors shall have the following format with lettering height of 25 mm using capital letters.

ANALYZER HOUSE NUMBER AH-**
--

**** Number as indicated on project drawings.**

9.1.3 Underneath of the above nameplate, the following nameplate shall be screwed to the doors with lettering height of 25 mm, using capital letters.

ANALYZER HOUSE PROTECTED BY ARTIFICIAL VENTILATION

9.1.4 The following warning notice shall also be screwed to all doors underneath the above mentioned notices. The applicable statements shall be selected from those indicated below (as may be applicable):

WARNING

- Doors shall be kept closed
- Risk of H₂S
- Flammable material shall not be introduced into the analyzer room without specifically permission and recording.

The lettering height shall be 20 mm. For capital letters with the lower case letters to scale the capital letters.

9.2 Drain, Vent and Condensation Systems

9.2.1 Drain, vent and condensate (if applicable) systems shall be clearly identified with name-plates and color coding.

9.3 Steam Supply

9.3.1 Nameplates shall be provided on steam header indicating the maximum pressure and temperature of the steam.

9.4 Ventilation Flow Detection

9.4.1 The flow detection device provide on the main inlet ducting shall be clearly marked (e.g. FIZ-001) and its housing shall be painted with bright red paint.

10. INSPECTION AND TESTING

10.1 General

10.1.1 The intent of this article is to provide only guidance for testing on-line process stream analyzers, sample transport lines, sample conditioning systems and utilities (air, water, steam, etc.). The contractor shall submit his proposed test procedure concerning these guidelines, for inspection body to be approved before precommissioning period.

10.1.2 All tests shall be carried out in the analyzer house or locally in the plant (depending on the analyzer location, inside or outside the analyzer house) before the analyzer are brought to the service.

10.1.3 Before testing any analyzer, all utilities shall be available at the required values of pressure, temperature and flow, etc. For analyzers installed inside the analyzer house, the safeguarding systems and the air ventilation, or air conditioning shall be operational, so that; a safe area and correct temperature exist for testing the analyzers.

10.1.4 Analyzers under test shall not be left running unattended.

10.2 Test Equipment

10.2.1 The following list of equipment is typical test equipment that every analyzer may require (specific test and calibration tools shall be prepared according to the analyzer vendor recommendations):

- 1)** Bubble flow meter,
- 2)** recorder (continuous 1 pen) 110 V AC/range 0-10 mV,
- 3)** recorder as above for 4-20 mA signal,
- 4)** multimeter with 0.1 mA/V for dc and ac signals,
- 5)** potentiometric mV meter,
- 6)** pH simulator,
- 7)** portable pH meter,
- 8)** calibrated and portable conductivity meter,
- 9)** set of precision manometers (Bourdon tube type),
- 10)** oscilloscope with accessories,
- 11)** resistance decade boxes,
- 12)** whetstone bridge,
- 13)** mA generator (4-20 mA),
- 14)** frequency meter,
- 15)** frequency generator,
- 16)** portable pneumatic/electronic convertor,
- 17)** high pressure test pump,

- 18) differential-pressure gages for calibration of transmitters,
- 19) test rig including sample cooling and sample heating facilities to run sample through analyzer system.
- 20) individual tool boxes (with appropriate tools for the tests to be carried out),
- 21) vacuum pump,
- 22) precision dead-weight tester,
- 23) glass thermometers -20 to +50°C/100°C/200°C/300°C,
- 24) portable moisture analyzer,
- 25) laboratory density indicators (high-precision),
- 26) hydrogen sulphide calibration kit,
- 27) set of laboratory accessories,
- 28) filters, graduate capacities glass pipettes, beakers, funnels, etc.,
- 29) leak tester,
- 30) large capacity blender for oil in water mixture,
- 31) syringe 10 and 100 CC; with fixed needle,
- 32) analytical filter paper size 24 cm, fast speed, natural finish, 0.2 mm (0.008 in.) thick,

10.3 Sample Transport Lines

The following tests shall be performed for sample transport lines.

10.3.1 Pressure testing

All sample lines installed shall be pressure tested by contractor, in accordance with the procedure used for pressure testing of general instrument impulse lines. Refer to IPS-C-IN-100.

10.3.2 Cleaning

10.3.2.1 General case

After the pressure test, all sample lines shall be cleaned with instrument air at a pressure of about 6 bar. The lines shall be flushed for a period of time between 5 and 10 minutes, as required.

Warning signs shall be erected at the blowing end of the pipes to avoid injury to personnel.

Note:

During flushing, the lines shall be disconnected from the equipment, at both ends.

10.3.2.2 Particular cases

For hygrometer and HCl analyzers, the following special procedures shall be used.

- a) The lines on both ends shall be disconnected and rinsed out with acetone.
- b) Flush the lines with instrument air or nitrogen in accordance with 10.3.2.1.

Note:

It may be necessary to clean the sample lines with 2 different types of solvent of opposite polarity, e.g. acetone and petroleum ether.

10.3.3 Leak testing

10.3.3.1 After pressure testing and cleaning, all sample lines shall be leak tested with instrument air (do not use process air). This test shall be performed at about 5-6 bar using leak test equipment, 2-3 bubbles per minute are acceptable. Careful check shall be performed to ensure that all parts under test can withstand this pressure, if not, they shall be isolated during the test. For this test, the lines shall be disconnected at both ends from the relevant equipment.

10.3.3.2 If instrument air is not available, leak test may be carried out with industrial nitrogen (oil-free).

10.4 Sample Pre-Conditioning

10.4.1 Leak test

Leak test shall be carried out with instrument air, as specified in 10.3.3.

10.4.2 Verification test

This test shall be carried out to verify that the equipment has not been damaged during transport or installation.

When a pump is a part of the pre-conditioning system, the following procedures shall be applied:

- a)** All electrical tests shall be carried out, i.e.; supply/start-stop switch, earthing, direction of rotation, etc. These tests have to be made by the contractor, inspected by Engineer and the relevant check form has to be attached to the analyzer check forms.
- b)** Inspection shall be performed to make sure that:
 - Gear boxes are filled with correct oil, if applicable.
 - Mechanical preliminary checks are made in accordance with manufacturer's instructions.
- c)** The system shall be disconnected from the lines and shall be run with a suitable sample using a temporary drum installed in such a way that correct NPSH requirements are met. The pump shall be run for at least ¼ hour.

CAUTION:

If any hydrocarbon sample is used, take all precautions for the classified area and:

- Never leave this equipment running unattended.
- Never run the pump without a sample.
- Install a fence around the equipment under test to avoid injury to personnel.

10.4.3 Other cases (pressure reducer station)

When a pressure reducer or vaporizer is used, a test shall be made with instrument air. Check shall be performed to ensure that reducer operates properly, and at the same time check on the relevant accessories shall be performed, e.g. gages. Process air for this check shall not be used.

10.5 Conditioning System

10.5.1 Leak test

Leak test shall be made with instrument air. The same procedures as described in 10.3.3. are applicable for this test as well.

10.5.2 Verification test

10.5.2.1 This test shall be carried out:

- a) With instrument air for gas application,
- b) With liquid hydrocarbon for liquid applications. In this case, the sample will be run through the conditioning system using a test rig (Appendix A).

10.5.2.2 During this test, check shall be performed to ensure that all parts (rotameter, gages, etc.) function properly. This test will not prove the efficiency of filters, coalescers, etc. It will only demonstrate that all parts are mechanically correct. All precautions shall be taken for the area classification when using hydrocarbon sample. Warning fences shall be installed around the area under test.

10.5.2.3 Samples shall not be drained to the plant main drain without Engineer permission. If the plant drain cannot be used, samples shall be collected in a temporary installed drum.

10.6 Interconnecting Tubing to the Analyzer

10.6.1 All tubing (samples, carrier gas, etc.), connected to the analyzer, shall be carefully cleaned. This shall be realized by disconnecting the lines at both ends and flushing them with clean instrument air or nitrogen. These lines shall be reconnected immediately after cleaning.

10.6.2 Carrier gas and detector lines for the chromatograph should be cleaned in accordance with the following procedure:

- 1) Disconnect the lines at both ends.
- 2) Rinse out the lines with solvent (about 250 ml of acetone per line).
- 3) Blow out the lines for at least 30 minutes with instrument air or nitrogen.
- 4) Reconnect the lines immediately.

10.7 Analyzer Electrical Supply

Contractor shall perform the checks to ensure that wiring to each individual power socket is correct. Electrical safety, e.g. earth connections, shall be verified.

10.8 Analog and Alarm Signals

These signals shall be checked in accordance with the procedure used for the other general instrumentation analog or alarm signals.

10.9 Analyzers

10.9.1 General

10.9.1.1 Analyzers shall be tested in accordance with the manufacturer's instructions.

10.9.1.2 Basically, all analyzers shall be checked with a suitable test sample certified by an authorized laboratory. The purpose of this verification test is to prove that the manufacturer's original calibration is still valid. Analyzers shall not be recalibrated unless an obvious discrepancy is found. The following test procedures shall be followed by the contractor:

- Before switching on, a complete wiring check shall be performed.

- After successful starting-up, warming up and functional check shall be carried out with a minimum of 4 hours continuous operation. During this test the repeatability shall be checked as follows:

- a) For discontinuous type measurement (GC, Cloud Point, Flash Point, etc.), the repeatability shall be demonstrated by the trend recording of the measured value.
- b) For continuous measurement (i.e. viscosity, RVP, etc.), the repeatability shall be demonstrated by switching off the sample (by hand) 10 to 20 times.
- c) For analyzers, where test samples are difficult to obtain or long-term stability is poor, checking shall be carried out with calibrated portable instrument (i.e. dew point measurement and conductivity).

10.9.1.3 After completion of the tests, the following items shall be performed:

- 1) For analyzers using a heavy viscous sample, rinse out all the circuits with a light sample.
- 2) For analyzers using light products, sample must remain in the circuits. For corrosive service, sample circuits shall be rinsed out with non-corrosive light sample.

10.10 Main Utilities Around the Analyzer House

10.10.1 Only a pressure test shall be performed on these lines, using normal procedures by the contractor. Equipment which cannot withstand this test (e.g. gages, filters, etc.) shall be checked at the maximum working pressure of the instruments or shall be isolated before pressure test.

10.11 Test Documents

A check list shall be provided for each analyzer, signed by contractor representative and Engineer.

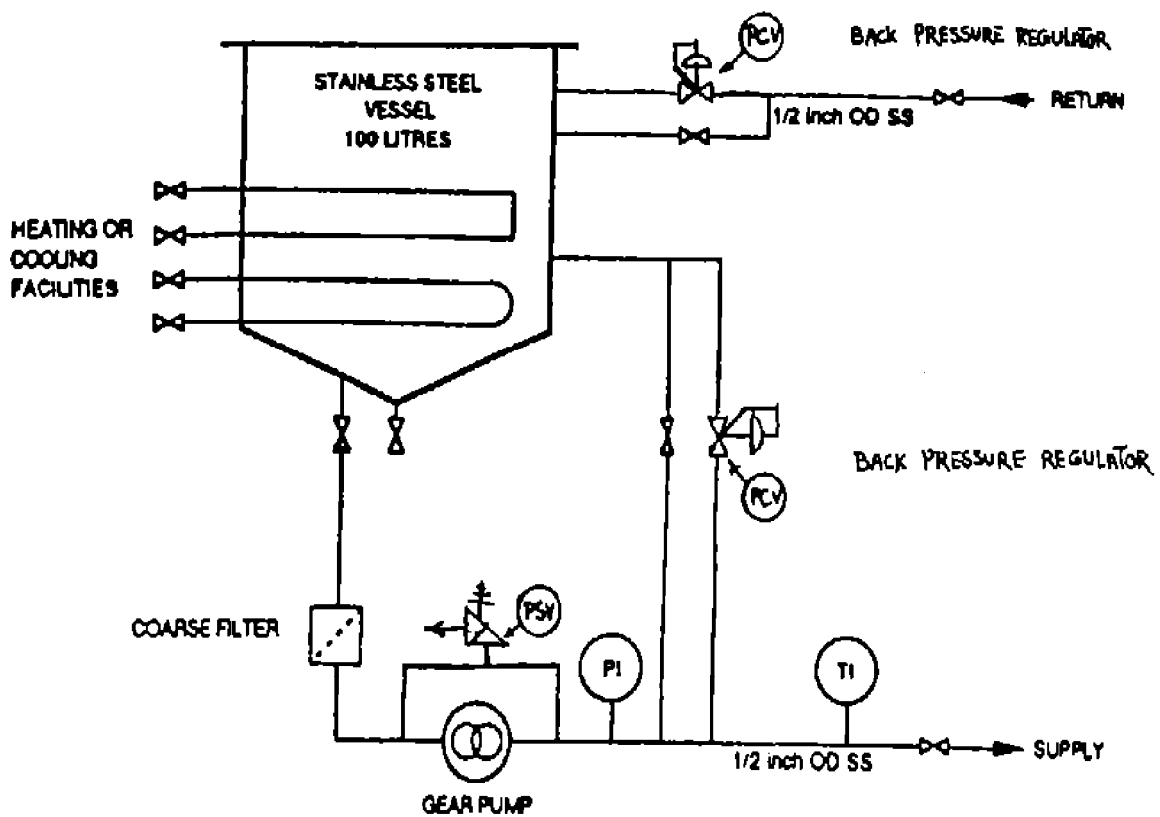
The following documents shall be included to the check list:

- a) Record of the verification test, (for typical forms refer to Appendix B).
- b) Wiring and piping drawings.

APPENDICES

APPENDIX A

TYPICAL TEST RIG FOR ANALYZER TESTING



If possible, use a penumatic driven gear pump at:

- A pressure of 10 bar approximately and,
- a flow of 0.06 dm³/sec.

All parts shall be installed on a suitable frame to facilitate transport and operation.

When used for viscous products, the whole system shall be steam or electrically heat traced and insulated.

APPENDIX B ANALYZER TYPICAL CHECK LIST FORMS

FORM No. 1: ANALYZER CHECK LIST INDIVIDUAL ANALYZERS

Tag No. Instrument Type

ITEM	CHECK LIST ACCEPTED	CONTRACTOR	ENGINEER	REMARKS
	1) Sample Take-Off Probe Drawing No.: Installation 2) Sample Return Tee(T) Drawing No.: Installation 3) Sample Take-Off Line Drawing No.: Materials Connections Installation Steam tracing Insulation Pressure test Cleaning Leak test 4) Sample Return Line Drawing No.: Materials Connections Installation Insulation Steam tracing Pressure test Cleaning Leak test 5) Pre-Conditioning Drawing No.: Installation Connections Steam tracing Insulation Leak test			

(to be continued)

APPENDIX B (continued)

ITEM	CHECK LIST ACCEPTED	CONTRACTOR	ENGINEER	REMARKS
	Electrical Protection (Fuses, braker, etc.) Earthing Electrical connections Verification test 6) Conditioning Rack Drawing No.: Installation Connections Steam tracing Insulation Leak test Verification test 7) Analyzer Drawing No.: Installation Connections Steam tracing Insulation HVAC and safeguarding System tested Electrical protection Earthing Electrical connections Interconnection wiring Verification test			

FORM No. 2: ANALYZER CHECK LIST GAS/HYDROGEN SULPHIDE DETECTION

	INSTALLATION				VERIFICATION TEST NUMBER				
TAG	ACCEPTED	NOTE	CONTRACTOR	ENG.	ACCEPTED	ACCEPTED	NOTE	CT	ENG.

PART 3**GENERAL-MATERIAL STANDARD**

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1. SCOPE

This Standard Specification covers the minimum general requirements for process on-line stream analyzers applied in Iranian Petroleum Industries for process control, monitoring and recording.

Also included, the specifications for analyzer system packaged with analyzer house by a System Integrator, with all specified analyzers.

2. REFERENCES

Throughout this Standard, the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor:

CENELEC (EUROPEAN COMMITTEE FOR STANDARDIZATION OF ELECTROTECHNIQUE)

EN 50.014	"General Requirement"
EN 50.015	"Oil Immersion 'O' "
EN 50.016	"Pressurized Apparatus 'P' " # NFPA 496
EN 50.017	"Powder Filling 'q' "
EN 50.018	"Flame Proof Enclosure 'd' "
EN 50.019	"Increased Safety 'e' "
EN 50.020	"Intrinsic Safety 'i' " # NFPA 493

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO-3171	"Petroleum Liquids-Automatic Pipeline Sampling" (1988)
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ISA (INSTRUMENT SOCIETY OF AMERICA)

S12.4	"Instrument Purging for Reduction of Hazardous Area Classification"
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IEC (INTERNATIONAL ELECTROTECHNIQUE COMMISSION)

# 79	"Artificial Ventilation for the Protection of Analyzer(s) Houses" (1990)
Part 16	

NFPA (NATIONAL FIRE PROTECTION ASSOCIATION)

NFC# 496	"Purged and Pressurized Enclosures for Electrical Equipment" (1982)
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API (AMERICAN PETROLEUM INSTITUTE)

RP-550	"Manual on Installation of Refinery Instrument and Control System", Part II, "Process Stream Analyzer" Section 1 through 11 (1985)
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OSHA (OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION)

	"Exposure Table OSHA Specification for Toxic Gases Safe Occupational Exposure Limit"
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3. GENERAL REQUIREMENTS

3.1 Packaged Instrumentation System (Prefabricated by System Integrator)

3.1.1 Prefabricated analyzer house specification

3.1.1.1 The System Integrator for the analyzer package shall provide standard whether proof prefabricated housing for the system. The analyzer house shall be totally transportable and removable with all instruments installed inside.

3.1.1.2 The System Integrator shall provide all details of construction of the analyzer house with detail layout of analyzer house equipment for Company's approval.

3.1.1.3 The System Integrator shall provide all necessary facilities and equipment to make the analyzer house package fully operational.

3.1.1.4 Generally all requirements required in IPS-G-IN-230/1 (General Engineering) shall be considered by System Integrator in design and construction of analyzer houses. (Chapters; 3, 4, 5 and 7).

3.1.1.5 When the analyzer system utilizes toxic gases, necessary precautions shall be made so that; under worst fault conditions, the concentration does not exceed safe occupational exposure limit as specified by OSHA (Occupational Safety and Health Association). Analyzers handling toxic substances shall be separately arranged in the analyzer house and clearly marked to be identified conveniently.

3.1.2 Safety facilities inside the prefabricated house

3.1.2.1 A low flow switch shall be provided for analyzer house ventilation system to indicate flow failure when flow falls below the equivalent of 60% of design flow, and shall initiate visible and audible alarms in the house and at a manned remote location.

3.1.2.2 If any equipment other than those suitable for Division II operation is provided in the analyzer house, then the following trip functions shall be provided:

- a) Immediate isolation of all non-certified equipment, in case of ventilation system failure.
- b) Immediate isolation of all wall sockets, in case of ventilation failure.

3.1.2.3 Flammable gas detectors shall be positioned in the analyzer house and provided by analyzer package System Integrator in accordance with the nature of the gases expected to be released within the house, either from the analyzer systems or via the ventilation system.

3.1.2.4 Gas detection system shall be provided with initiation of audible and visible alarms inside and outside of the analyzer house with yellow flashing beacon outside of the house.

3.1.2.5 On removal of the hazardous conditions as indicated by the gas detection equipment (below 20% LEL), power shall not be restored to isolated equipment until at least 10 analyzer house volumes of air have been exchanged. This shall be automatically controlled via a delay-on timer and activation of a local manual reset facility which all shall be provided by analyzer package System Integrator.

3.1.2.6 Purge failure trip functions shall be provided for all purged analyzer enclosures in addition to those associated with ventilation failure and/or flammable gas detection. Purge failure in any circumstances shall initiate visible and audible alarms.

3.1.2.7 If a toxic gas is handled inside the house, then toxic gas detection system shall be provided for the analyzer house to detect the toxic gases encountered.

3.1.2.8 Detection of any toxic gas above preset alarm limits shall initiate a visual and audible alarm in the house and at a remote manned location. Toxic gas detection shall initiate a visual alarm located on the outside of the house, normally common with flammable gas detection light using a yellow flashing beacon.

3.1.2.9 Manual call points (fire alarm push-buttons) shall be provided on the outside wall of the house next to the doors.

3.1.2.10 Fire Detectors shall be provided in the house in the form of smoke or heat detectors.

3.1.2.11 CO₂ automatic extinguishing system shall be provided in accordance with IPS-E-SF-160 Standard.

3.1.2.12 Fire detection shall initiate a visual and audible alarm in the house and at a remote manned location. A red flashing beacon common with toxic light shall also be provided for fire detection alarm outside the analyzer house.

3.1.2.13 Fire detection provided shall automatically initiate the isolation of;

- a) Any pipework entering the house that contains flammable materials.
- b) ventilation fans,
- c) all electrical supplies to the house,
- d) the system shall automatically; shut off the ventilation air, isolate all ventilation inlet and outlet louvers.

3.1.3 Ventilation requirements for the prefabricated house

3.1.3.1 Ventilation equipment shall be provided with suitable rating to dilute and dissipate any dangerous release within the analyzer house or cabinet.

3.1.3.2 The induced ventilation calculations shall use as a basis a minimum of 10 changes/hour or that necessary to:

- a) Dilute escaping vapors from the rupture or failure of the most hazardous sample or service line to less than 20% LEL around any potential means of ignition especially those liquids which vaporize at ambient temperature.
- b) Dilute to below dangerous limit any toxic gases/vapors introduced into the analyzer house by accidental rupture of any sample or service line within the house.

3.1.4 Heating and cooling for the prefabricated house

3.1.4.1 Thermostatically controlled heater banks shall be provided to give a maximum exit air temperature of 55°C with the heater full on. The air flow across the heater shall not exceed the equivalent of 20 to 30 changes of air per hour in the house in a manner to control the temperature inside the building within limits of 10°C and 30°C under extreme conditions.

3.1.4.2 Warm air shall be distributed in the lower half of the analyzer house as close to the lower vents as possible.

3.1.4.3 The surface temperature of the heater shall be suitable for gas group encountered and shall be below 200°C in any circumstances.

3.2 General Analyzer Requirements

3.2.1 Safety requirements

3.2.1.1 All non-explosion-proof equipment shall be purged if they are located in Division II hazardous areas, even if there is no internal source of release of flammable material in these equipment.

3.2.1.2 Purging of equipment with an internal source of release of flammable material shall have the function of preventing any build-up from any flammable material leakage within the equipment by dilution or inerting.

3.2.1.3 All analyzers measuring systems shall be certified by UL or other approved bodies for Class 1, Division II, Group B,C and D hazardous area. The analyzer measuring systems shall also use purging system to make it suitable for Class 1, Division I, Group B,C, and D.

3.2.1.4 The analyzer system itself shall be certified according to the requirement of the related classified area by authorized agencies.

3.2.2 Electrical requirements

3.2.2.1 All analyzer equipment shall work with 110 V ac/50 Hz or 24 Vdc, as specified, power system supplied by the Company.

3.2.2.2 Electrical entrance to the analyzers shall be provided by means of M20 glands.

3.2.3 Analyzer Communication to Instrumentation/Control System

3.2.3.1 The following signal transmission types shall be provided for all analyzers, as may be applicable :

a) Continuous:

Typically from PH, Infra-Red, Oxygen, Viscosity analyzers to be 4 to 20 mA dc and isolated type.

b) Cyclic:

Typically from chromatographs to be 4-20 mA and isolated type.

c) Digital:

This signal may be provided in addition to the 4 to 20 mA signal for communication to the DCS if this requirement is requested through the data sheet.

3.2.3.2 The following signals shall be communicated between the analyzer house and the control room:

a) System alarms,

b) "Come Read" signal-usually a contact change-over at the end of the cycle of a cyclic analyzer informing the read-out instrument that new data is available.

c) "Out of Service Alarm" Informing the read out instrument that the analyzer is not in service.

d) "Validating/Calibrating Status" To inform the read-out apparatus that the analyzer is in calibrating or validating mode.

e) "Validating/Calibration Request" Usually a signal from the control room, requesting the analyzer to perform a validation or calibration sequence.

f) "Stream-Selection" Identification of stream in use, sent from analyzer.

3.2.3.3 On loss of the purge, not only the mains power to the purged analyzer shall be isolated but also the signal transmission lines shall be isolated.

3.2.3.4 The analyzer vendor shall provide necessary gateways for digital outputs for communication to the DCS if that is requested through the project requirement.

3.2.3.5 Individual analyzers shall be capable of generating alarms specific to their own conditions with regard to their results. These alarms shall be in the following categories:

a) The result is wrong and shall not be used for control.

b) The result will be wrong if the analyzer does not receive attention and may be used for control at the moment.

3.2.3.6 Analyzers producing a non-linear output shall perform the required linearization by suitable transmitter, provided by the vendor.

3.2.3.7 During the validation/calibration cycle, the signal for the last analyzer cycle indication shall be frozen by the analyzer.

3.2.3.8 Vendor shall pay particular attention to ensure prevention of any plant DCS or Computer system confusion or misinterpretation during the validation/calibration cycle of a cyclic analyzer.

3.2.4 Sampling systems

3.2.4.1 Sampling systems shall be designed to prevent any contamination or damage to the analyzer in case of plant upset conditions. If such a precaution is not possible, then suitable protective alarm and shut-down facilities shall be provided for the analyzer system.

3.2.4.2 Samples shall be withdrawn by probes, protruding into the process line to avoid wall effects.

3.2.4.3 Design and calculation of sample probes shall be performed by vendor to ensure that sampling failure cannot occur during the analyzer operation.

3.2.4.4 The type of selected probe depends on the temperature and chemical composition of the environment or process stream. Stainless steel shall be used for temperatures up to 816°C. For extremely corrosive samples, materials such as Hastalloy, Monel, and Inconel are recommended.

3.2.4.5 Sample take off systems shall be considered, so that:

- 1) Fast circulating loops shall be provided generally to reduce sampling system time lag with the minimum waste of product.
- 2) The sample stream from the fast loop fed to the analyzer shall normally be provided with filtering through a self-cleaning by-pass filter.
- 3) Specially installed pumps in fast loops shall be avoided because of their extra maintenance requirements. If the installation of the pump is inevitable, then the pump and associated filter shall be selected of a type not to degrade the sample.
- 4) All facilities required shall be provided to indicate and regulate adequate flow in the loop.

3.2.4.6 Sample by-pass system shall be provided in sample conditioning system, so that:

- 1) By-pass system may be used in order to reduce the sampling system lag, e.g., when vaporizing liquids applied for pertinent gas analysis.
- 2) Particular attention must be paid to the location of vent or drain when toxic or flammable substances are handled. The bypass flow must be kept to minimum to minimize any risk to the personnel or equipment if the by-pass causes such risks.

3.2.4.7 Sample recovery systems shall be provided in sample conditioning system, so that:

- 1) To return the low pressure products back to the process by suitable mechanical means.
- 2) The systems shall be typically a collection vessel with a pump controlled from level switches within the collecting vessel (for liquid service).

3.2.5 Sample conditioning system

3.2.5.1 The sample conditioning system shall be provided by the analyzer Vendor complete with all components as specified in article 3.2.5.2 with suitable housing to be mounted outside the analyzer house according to the project requirements.

3.2.5.2 The sample conditioning system shall be designed to supply the sample at the required analyzer inlet condition requirements. The sample conditioning system shall be made from the following main components, as may be applicable:

- filter(s);
- pressure reducer(s);
- variable area flow meter(s);
- relief valve(s);
- multi-stream switching valve(s);
- excess flow valve(s);
- cooler(s);
- heater(s) for heating or preventing freezing;
- vessel(s) for test /calibration services;
- tubing and compression fittings.

3.2.5.3 For general applications, all wetted parts shall be made of stainless steel. The compression fittings and tubing shall be in inch sizes, with NPT threads.

3.2.5.4 Sample conditioning systems shall have facilities for flushing, venting and/or draining, with vent and/or drain valve(s).

3.2.5.5 Stainless steel tubing shall be provided for air lines and should be blue color coded with paint or PVC tape, at intervals of approximately 100 mm .The width of the coding shall be 10 to 15 mm.

3.2.5.6 Pressure gages for sampled fluids should have a 100 mm dial and shall be provided with a inch NPT threaded connection.

3.2.5.7 Pressure gages which cannot be depressurized in the conditioning system, shall be provided with isolate and vent valves.

3.2.5.8 Instrument air supply and nitrogen supply lines shall be provided with a filter/reducer complete with a pressure gage and blow out protection. The nitrogen filter/reducer set shall be of non-bleeding type.

3.2.5.9 Special attention shall be paid to the following:

- 1) Solenoid valves shall be applied only for switching instrument air and nitrogen. For all other fluids a pneumatically operated valve used in combination with a solenoid valve shall be provided. The pneumatic actuator shall have a direct-coupled mechanical position indicator.
- 2) Components or parts thereof made of glass, shall not be applied for flammable and toxic/noxious fluids.
- 3) Variable-area flow meters shall have a metal metering tube.
- 4) Relief valve(s) shall be installed to protect those components installed in a system which have a limited pressure rating, e.g., sample conditioning vessels and glass-containing components. The relief valves shall be connected to a vent or a drainage system, as required.

3.2.5.10 The total amount of flammable fluids flowing to the analyzer shall be limited by an excess flow valve.

3.2.5.11 Cooling or heating, as appropriate, shall be provided in the sample conditioning system for analyzers requiring a sample inlet temperature within specified limits. Where the cooling water temperature is too high, cooling by means of refrigeration or other mechanical cooling shall be considered.

3.2.5.12 For analyzers which require liquid samples for testing and calibration, a vessel bolted to the sample conditioning rack, shall be provided.

3.2.5.13 All components shall be installed on a stainless steel mounting plate, which shall be fixed to the sample conditioning rack with flat, countersunk headed, stainless steel bolts. The sample conditioning rack shall be either wall mounting or freestanding type, according to the application.

3.2.5.14 Components should be attached to the mounting plate with bolts and nuts, the nuts being permanently fixed to the mounting plate. Special attention shall be paid to the position of the components in relation to the connection to be made. Components, such as; ball valves and non-return valves, may be supported by their connecting by means of stainless steel attachments adjacent to the tubing connections. Non-metallic spacer material, e.g. Teflon hose, shall be applied to isolate the tubing from the supports.

3.2.5.15 All incoming and outgoing connections shall be identified with an engraved nameplate. Components, such as; relief valves, excess flow valves, and variable-area flow meters shall be provided with nameplates showing their settings.

3.2.5.16 Vendor/Manufacturer shall provide complete sample conditioning system drawings with components list and specification with his bid proposal, to be evaluated by the Company.

3.2.6 Analyzer equipment considerations

3.2.6.1 The use of individual or multiple prefabricated analyzer equipment should be considered in order to reduce site installation work. Such a prefabrication may include sample conditioners, analyzers, air and electrical distribution, cooling water, water distribution or coolant circulating system piped and wired on a common frame. The design shall permit testing of the entire assembly before dispatch to site and shall be arranged for convenient removal for off-line maintenance.

3.2.6.2 A schedule of recurring maintenance and adjustment operations shall be prepared and the necessary environment for these operations shall be specified by the vendor and shall be provided for all analyzers purchased.

3.2.6.3 The analyzers transmitters shall generally be equipped with local indication.

4. SHOP INSPECTION AND TESTS

4.1 General

4.1.1 Analyzers are categorized by many variety of applications and spectrum of design complexity that only a guideline will be presented herein to be considered by analyzer vendor for preparation of the inspection and test procedures, to be studied and approved by the Company.

4.1.2 Inspection is defined as the non-functional verification of the physical characteristics of an analyzer or analyzer system against the associated documentation. Non-functional verification can include visual inspection or analysis, including reduction or translation of data, analysis of factory test data, review of analytical data, or performance of detailed analysis.

4.1.3 Test is defined as the functional verification of an analyzer and includes actual operation of the analyzer and analyzer system.

4.1.4 The inspectors representing the Company shall have the right of entry to the Vendor plants including all Sub-Vendor's plants where work on or testing of the equipment and instrument is being performed. The Company reserves the right to reject individual equipment or instruments for bad workmanship or defects.

4.1.5 Functional test shall be performed on the analyzer system that has been warmed up and stabilized according to the manufacturer recommendation.

4.1.6 Performance test of analyzers must be done with standard calibration gas or liquid (where applicable).

4.1.7 The charts and results of final factory calibration shall be supplied as standard data sheets for the analyzer.

4.2 Inspection Procedures for Analyzer Systems

The analyzer systems can be partitioned into three distinct categories for the purpose of inspection and preparation of inspection procedures. These categories are; the prefabricated analyzer house, the analyzer, and the sample conditioning system.

4.2.1 Prefabricated analyzer house

The analyzer house shall be inspected for compliance with IPS-G-IN-230/1 and the pertinent Vendor drawings.

4.2.2 Process stream analyzer

Complete factory test procedure for the analyzer shall be furnished to the Company assigned inspectors. This procedure shall include test sample composition, charts, records, test results, and settings and adjustments that apply to the specific analyzer.

4.2.3 Sample conditioning system

The sample conditioning system is the combination of components or modules installed directly upstream of an analyzer inlet, used to prepare process samples for analysis. Examples of modules that are used include; filters, vaporizers, reducing regulators, scrubbers, separators, and temperature controllers. The system shall be checked for compliance with Vendor approved drawings and specifications.

4.3 Factory Acceptance Test (FAT)

4.3.1 General

4.3.1.1 Inspection shall be conducted at the manufacturer's factory or at the facility of an analyzer System Integrator who has the contract or sub-contract to furnish a package with several analyzers, complete with sample system, racks, and prefabricated analyzer house.

4.3.1.2 All inspection and test works for individual analyzers shall be performed in the manufacturer's shop.

4.3.1.3 Craftwork performed in the shop shall be inspected and tested for acceptance at the source, prior to shipment to the site location for installation. This craftwork shall include; fabrication, painting, mounting of equipment, piping and wiring.

4.3.1.4 The manufacturer shall provide all inspection and test equipment required for the Company assigned inspector and shall correct all deficiencies or malfunctions detected.

4.3.1.5 Factory Acceptance Test checkout will be divided into two parts; inspection and functional testing. Inspection shall include a visual check of the instruments and equipment against specifications and shall include a leak test of piping and tubing. The arrangement of equipment for accessibility and craft workmanship shall also be reviewed in inspection period. Functional testing shall emphasize on the total system operation, as well as demonstrating the ability of the analyzer to make the required analysis with a known sample, as a stability test.

4.3.2 Precheckout preparations

The final vendor's factory inspection must be completed and the system calibration must be performed by the analyzer vendor before arrival of Company's assigned inspectors to conduct checkout of the analyzers. As part of the precheckout preparation, necessary arrangements must be made, in advance, to set up the system and/or systems complete with sample, sample conditioning cabinet, the analyzers to be checked out, and any pertinent control units.

4.3.3 Checkout reference documentation

The following documents shall be used as working references during checkout procedures on analyzers:

- 1) Purchase order file, complete with copies of purchase order, supplements, specifications, and correspondence.
- 2) Vendor's data file, including electrical and piping drawings.
- 3) Vendor's service parts manual and instruction manual.

The Vendor shall provide any information or documentation requested by the Company's inspectors which are deemed to be necessary for performing the test and inspection by Company's inspector's judgment.

4.3.4 Final Acceptance Test

4.3.4.1 Visual inspection shall consist of visually verifying that all features of the quotation or purchase order are included. With the factory check sheet as a guide, all hardware shall be visually checked for defects and misalignment and their proper locations. The following specific visual checks shall be made:

- 1) The sample conditioning apparatus shall be checked for completeness and for workmanship of the tubing.
- 2) The wiring to the terminal boards shall be visually inspected for neatness, labeling, and compliance with codes.
- 3) The case dimensions shall be verified against any certified dimensional outlines to preclude discrepancies when panels are mounted.
- 4) The model number of the components shall be checked against the specification and the purchase order.
- 5) The materials shall be checked for appropriateness of use with the particular stream being analyzed.

4.3.4.2 Operation testing shall include the following:

- 1) The factory test shall be an operating test to demonstrate that the analyzer's performance complies with the purchase order specification.
- 2) Test shall be performed only after the system has been warmed up and stabilized in accordance to the manufacturer warm-up time recommendation.
- 3) Results of final factory calibration and testing shall be reviewed.
- 4) Leak testing shall be done on the entire system.
- 5) The performance of the analyzer during a run on calibration gas (or liquid, or mixture) shall be witnessed.
- 6) Reproducibility shall be demonstrated continuously for a minimum period of 8 hours using one or more standard samples.
- 7) Calibration shall be demonstrated with a test sample giving approximately one-half scale reading for the component of interest. The concentration of the component of interest in the test sample shall be at least 25 percent of span different from the concentration of the same component in the standard sample used for the reproducibility test.
- 8) On multi-stream analyzers, operation of the auto-select and/or manual-select switches and valves shall be verified.
- 9) The range of the recorder used to track the analysis shall be verified against the range given in the specification. If a transducer is used to condition output signals, the signal levels for compatibility with furnished panel-mounted components shall be verified.
- 10) The tag number, date of test, identification of each peak or trace, attenuator settings, and signatures of test personnel shall be recorded for Gas Chromatographs.

11) A punch list of all items requiring correction shall be prepared by the Company inspector.

12) An inspection report listing the tests performed and the results obtained shall be signed by Company's inspector.

4.4 On-Site Inspection and Test

4.4.1 On-site inspection shall be made prior to installation to verify that the analyzer and the documentation concur. The documentation used for this purpose shall include; purchase order, engineering specifications and drawings. This type of inspection shall be performed on all analyzers and systems.

4.4.2 The important inspection program at the site is the performance of any inspections that were not performed at the vendor location for some reasons, in a manner that the redundant testing to be minimized.

4.4.3 A careful inspection shall be made to determine any damage that may have occurred during shipping.

4.4.4 Final loop checking and functional testing of the analyzer system shall be performed after the installation has been completed.

4.5 Checklists for Test and Inspection Procedures

4.5.1 The specific components listed in Appendix A 1, Table 2, shall be checked, at a minimum, for the items listed. The tests or inspections listed shall be performed on the components during acceptance testing, either at the vendor location or at the site. For each specific analyzer system, additional checklist items may be required as defined in specific projects.

5. TRAINING

5.1 General Training Requirements

5.1.1 The vendor shall provide full description of his training program in his bid proposal considering the requirements mentioned herein.

5.1.2 Training of personnel involved with analyzers shall be divided in two general categories;

- Instrument engineers, responsible for application (professionals)
- Instrument technicians, inspectors which are responsible for maintenance. (specialists)

5.1.3 Professional training program shall focus on the capabilities and limitations of specific analyzers and on the experiences of other analyzer users in particular process applications.

5.1.4 Maintenance training must include general background updating of the personnel, as well as specific training on analyzers. The background knowledge listed below must also be taught to specialists assigned to analyzer maintenance.

- Pertinent chemistry, physics, electronics, hydraulics pertinent to each specific analyzer.

5.2 Training Course Requirements

5.2.1 Vendor shall provide training courses for their proposed analyzers. These courses shall be detailed in their proposal for Company's engineers and technicians.

5.2.2 Vendor Training shall be of high quality using a format that combines classroom sessions, demonstrations, and Hands-On familiarization.

5.2.3 The classroom portion shall cover the principles and theory involved in the design of the analyzers and the proper application of the analyzers to the process.

5.2.4 The Hands-On training shall be designed to teach proper functioning and maintenance, including calibration, testing, diagnostic procedures, adjustments and tuning, and assembly and disassembly.

6. PREPARATION FOR SHIPMENT

6.1 Each "Shipping Section" of stationary structures shall be provided with removable lifting hook suitable for crane hooks or sling. Shipment should not be carried out unless the analyzers system inspected and signed by the Company inspector. If this inspection requested through the project requirement.

6.2 Packed for shipment in wooden cases, each instrument shall be enveloped in a polyethylene bag containing silica gel or similar dessicating compound. To avoid damage during shipment or handling, each item shall be embedded in shock absorbing filling material.

6.3 Each instrument shall be provided with a tag specifying the unit it belongs to. When instruments are packed in several layers in the same case, horizontal wooden partitions shall be provided, suitably spaced and secured to case frame. Mercury and other chemicals supplied with instruments shall be shipped in separate cases. Case's marking must indicate type of storing advised by the Vendor.

Example:

Open air, under roof, closed store.

6.4 Packing and marking shall be in accordance with pertinent IPS Standards.

7. DRAWING AND DOCUMENT REQUIREMENTS

All drawings provided for analyzers shall show equipment as specified and ordered. Typical drawings are not acceptable unless they are revised to show only the equipment being furnished. Ten (10) prints, one reproducible and floppy diskette shall be supplied to the Company prior to equipment Factory Acceptance Test. Drawing shall be supplied as follows:

7.1 Complete Structural Drawings Showing

- a)** Arrangement.
- b)** Dimensional plan and elevation, front view, and other elevation views, if applicable.
- c)** Conduit entrance locations and dimensions.
- d)** Incoming and outgoing power cable terminator positions.
- e)** Customer wiring terminal block locations, and all other terminal block locations.
- f)** Anchor bolt locations.
- g)** Grounding connections.
- h)** Weight of equipment.
- i)** Overall dimensions in millimeters.

7.2 Schematic Diagrams

- a)** Schematic diagrams shall be furnished for each control scheme.
- b)** Each Schematic diagram shall show all terminal block numbers, control devices and device contacts, each of which shall be labeled with its proper device functional number.

7.3 Detailed Connection (Wiring) Diagrams Showing

- a) All wiring within each unit,
- b) all interconnecting wiring between units,
- c) identification of all terminals and terminal blocks,
- d) clear identification, by some distinguishing method, of all wiring which is to be installed by Company. This shall include spare auxiliary contacts and relay contacts which shall be wired to terminal blocks for future Company's use.

7.4 Operation and Maintenance Manuals

7.4.1 Complete operation manual of the individual analyzer system shall be provided for each analyzer supplied in the contract in 10 copies.

7.4.2 Complete maintenance manual of the analyzer system shall be provided for each individual analyzer supplied in the contract in 10 copies. Complete parts list for all components and equipments used in analyzing system shall be provided to the Company.

7.5 Sample Conditioning System Drawings and Documents

7.5.1 A set of drawings shall be prepared, to scale, by the Manufacturer/Supplier for all sample conditioning systems showing in detail:

- the correct position of components on the mounting plate;
- the arrangement of the interconnections;
- the method of supporting;
- a list of materials required.

7.5.2 The drawings shall be assembled in one set for each sample conditioning system, complete with cover sheet, index sheet, list of materials, list of settings, technical information and where applicable, test certificates.

7.5.3 The Manufacturer/Supplier shall include an operating instruction for start-up and maintenance of the sample conditioning system.

7.5.4 The Manufacturer/Supplier shall send the drawings to the Company representative for comments, at least one month before construction work commences.

7.5.5 The copies of the as-built drawings shall be shipped with the sample conditioning system. One set of transparent as-built drawings shall also be provided.

7.5.6 If the Manufacturer/Supplier intends to use a computerized system for the handling of components and installation materials, he shall obtain a written approval of the Company on the format and contents of the computer output sheets or diskettes sheets. The sheets or diskettes should provide the following information, minimally:

- itemized material requirements per each conditioning system;
- total requirements per item;
- information of material ordering.

7.6 Analyzers Specific Requirements

7.6.1 Detailed calibration curves shall be provided for analyzers.

7.6.2 The following information shall be provided by Vendor for Gas Chromatographs:

- All flow rate details at column, detector reference, backflush, vent, etc.
- Pressure, flow and temperature values necessary to check for proper operation of the instrument.
- All detector settings, such as; voltage, current, etc. shall be specified.
- Test sample compositions shall be clearly specified.

8. GUARANTEE

Vendor shall guarantee the following when the instrument is operated in accordance with the written operating instructions.

8.1 Effluent rate and quality under conditions per specification.

8.2 Instrument is free from fault in design, workmanship and material to fulfill satisfactorily the operating conditions specified.

8.3 The guarantee shall be valid for the duration of one year after start up or 36 months after shipment.

APPENDIX A

A.1 TABLE 1 - CHECK LIST OF ANALYZER SYSTEM INSPECTION

(to be continued)

APPENDIX A (continued)

5	Mechanical and Finishing Inspection a) Doors b) Panic bolts c) Adjustable louvers d) Paint e) Others	_____	_____	_____
6	Fast Loop and Sampling System a) Check as-built drawings b) Easy accessibility c) Filter d) Pressure e) Pressure regulators f) Pressure-relief valves g) Flowmeters h) Temperature indicators i) Pump j) Cooler k) Stream indicator (function) l) Stream selection solenoid valves (function) m) Level gages n) Three-way ball valve (operational) o) Valves (operational) p) Check valve q) Local indicator r) Purge system s) Pressure switch	_____	_____	_____
7	Functional Test a) Fast loop b) Sample conditioning system	_____	_____	_____

(to be continued)

APPENDIX A (continued)

**TABLE 2 - CHECK LIST OF TEST PROCEDURES FOR ANALYZER SAMPLE
CONDITIONING SYSTEMS**

ITEM	COMPONENT	ITEM FOR TEST AND INSPECTION
1	Filters/strainers	<ul style="list-style-type: none"> - Rotating filters turnable by hand - Mesh size of fixed filters - Pressure drop, when possible - Proper materials, retention rating, proper drainage
2	Pressure reducers	<ul style="list-style-type: none"> - Response of output pressure to adjustment
3	Vaporizers	<ul style="list-style-type: none"> - Refer to manufacturer's instructions
4	Pressure gages	<ul style="list-style-type: none"> - Visual check of zero point - Materials of wetted parts
5	Coolers	<ul style="list-style-type: none"> - Materials of construction
6	Coalescers	<ul style="list-style-type: none"> - Materials of construction - Installation of element
7	Pumps	<ul style="list-style-type: none"> - Flow rate versus discharge pressure
8	Flowmeters	<ul style="list-style-type: none"> - Response to flow change - Materials of construction - Cleanliness
9	Relief Valves	<ul style="list-style-type: none"> - Setpoint - Materials of construction
10	Nonreturn valves	<ul style="list-style-type: none"> - No visible reverse flow
11	Local indicators	<ul style="list-style-type: none"> - Comparison of reading against receiver
12	Valves (including solenoid)	<ul style="list-style-type: none"> - Tight shutoff, where necessary - Materials of construction
13	Drain lines/vent lines	<ul style="list-style-type: none"> - Adequate size, proper materials, slope

PART 4**ON-LINE PROCESS STREAM ANALYZER SPECIFICATION**

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1. SCOPE

The scope of this Part of the analyzer standard is to provide general technical specification for some commonly used analyzers in Iranian Petroleum Industries.

Application of this Standard shall be considered in conjunction with Part 3 of this Standard "General-Material".

In case that; the analyzers are purchased as a total packaged system, the Part 1 of this Standard shall also be included in the technical document package, to be considered by analyzers package supplier.

SECTION 1. GAS CHROMATOGRAPH ANALYZER

1.1 Applicable Standards

ASTM E 840-81 "Practice for Using Flame Photometric Detectors (FPD) in Gas Chromatography"

1.2 Measuring System Requirements

The analyzer system equipment shall include; chromatographic columns, sample injection and switching valves, detectors, temperature controller, flow controls of the carrier gas and carrier mediums, and all necessary components to perform the specified job in the project.

1.2.1 Chromatographic column and pertinent oven

1.2.1.1 The Gas Chromatograph shall be equipped with; high quality, stainless steel, low thermal mass, large ovens.

1.2.1.2 The ovens shall be provided with a stable temperature control to control the temperature within $\pm 0.1^{\circ}\text{C}$.

1.2.1.3 The oven temperature shall not exceed 80% of the ignition temperature of any gas sampled by the analyzer and shall be UL approved.

1.2.1.4 The operating temperature range shall normally be between 50°C and 225°C .

1.2.1.5 Ovens shall be provided with ventilation mechanism to be automatically opened at the end of every temperature programmed chromatograph run. The ventilation system shall be preferably of back wall mounted fan with enough power and air flow distribution characteristics to cool-down the oven from maximum temperature to 50°C in less than 7 minutes.

1.2.1.6 The chromatographic column shall consist of a suitable length of tubing packed with the suitable materials required for the particular component separation. One set of spare column shall be supplied with the chromatograph.

1.2.1.7 The chromatograph shall have sufficient quantity of columns to be capable to perform all analysis indicated in the project data sheets, as required. The columns shall be capable to perform the desired separation and shall be highly stable.

1.2.1.8 The tubing material, packing solids, and liquid coatings must be inert to all sample components and the carrier gas employed (carrier gas shall be considered as Nitrogen, preferably).

1.2.1.9 Column packing materials must be selected by vendor to have a high surface area, uniformly packed, attrition resistant, and must offer low resistance to flow.

1.2.1.10 The temperature controlled zone of the GC shall be well insulated and shall operate at a temperature well above the maximum ambient temperature.

1.2.2 Sample injection and switching valves

1.2.2.1 The sample injection valve shall be of a construction to introduce a truly constant volume of sample into the upstream end of the chromatographic column.

1.2.2.2 The valves shall be of the pre-load assembly to hold the rotor sealed inside the valve body during operation.

1.2.2.3 The valve actuator shall be of pneumatic type preferably to be used in conjunction with an E/P converter, provided with the analyzer assembly.

1.2.2.4 The valve design shall allow mounting within the oven compartment of the GC while the actuator is mounted outside the GC compartment. The valve material shall be preferably made of hastalloy C.

1.2.2.5 The sample valve shall have a proven design and precise work-manship in every manner, to minimize peak tailing and baseline separation problems.

1.2.2.6 The sample injection and column switching valves shall be an integral part of the analyzer and vendor is responsible for their design and efficiency. The Company will test and examine all features of the analyzer to assure adequacy from; safety, maintenance, and operational standpoints.

1.2.3 Detectors

1.2.3.1 Detectors in general refinery service shall be either; Thermal Conductivity Detector (TCD), Flame Ionization Detector (FID) or Flame Photometric Detector (FPD), according to the process analysis requirements.

1.2.3.2 The TCD or FID shall be of universal hexagonal fitting type with optional installation and removal facility.

1.2.3.3 The Detector shall be provided with temperature controlled heated block on suitable accessible location of the analyzer enclosure. The detector controller shall be located in a separate compartment as close as possible to the detector in order to minimize the detector noise level.

1.2.3.4 Detector ignition system for FID shall be of reliable type with pertinent ignition switches located on a convenient location on the analyzer panel.

1.2.3.5 A shut-off system shall be provided to operate on detector needle valve to shut-off and turn-on again the flow without having to readjust the original needle valve setting.

1.2.3.6 The analyzer shall include a detector amplifier to boost and standardize the detector signal before transmitting the signal to the programmer.

1.2.4 Carrier gas system

1.2.4.1 The carrier gas used shall be suitable for the analysis performed and type of detector employed. Anyhow preference will be granted to Nitrogen.

1.2.4.2 Expensive gases such as Helium or Argon shall be avoided for carrier gas, as far as possible.

1.2.4.3 Hydrogen may be used for carrier gas as the last choice. All precautions and preventive measures shall be provided when Hydrogen is employed.

1.2.4.4 The storage bottle and high pressure regulator provided, shall be of high quality, multistage, non-bleed type to prevent loss of carrier gas.

1.2.4.5 The carrier gas control system shall consist of a precision pressure regulator with needle valve or a differential pressure regulator and a miniature rotameter.

1.2.4.6 The flow rate of carrier gas shall be established at the analyzer vent using a bubble flowmeter, or other high accuracy means.

1.2.4.7 Care must be taken on rotameter installation to prevent air leakage into the system. The vent system must be carefully designed to prevent pressure variations in order to maintain a constant flow of carrier gas.

1.2.4.8 Threaded connections shall be minimized and must be of non-lubricated type and shall not be doped with materials that can introduce contaminants into the system.

1.2.4.9 All drying equipment shall be provided by the vendor to ensure the carrier gas to be dry and clean.

1.3 Analyzer System Requirements

1.3.1 Chromatograph programmer/controller

1.3.1.1 The analyzer shall be; on-line, stand-alone, process gas Chromatograph and shall be capable to be used in distributed analyzer system network.

1.3.1.2 Microprocessor based programmer/controller shall be provided for automatic chromatograph operations and data presentation. The primary function of programmer shall be gathering and processing data from the analyzer and transmitting the results to recording, monitoring or process control devices.

1.3.1.3 The operating system of the microcomputer programmer shall provide user-friendly operator interface allowing complete programming, editing and storage of minimally twelve comprehensive GC analysis methods.

1.3.1.4 The programmer shall also provide automatic baseline subtraction and oven temperature recording to be further printed and displayed on the printer and LCD display of the analyzer. In addition, the system shall be equipped with the necessary software and hardware to include; stop-watch for time recording and chart marking, program for calculation of column flow, average carrier gas velocity, split ratio and column dead-time.

1.3.1.5 The programmer shall; switch the chromatograph and selector valves, transform the detector signal into usable form, provide signals for component gating, and perform house-keeping and trouble shooting functions. The programmer shall be mounted remotely from the analyzer and shall be connected to the analyzer by a multiconductor cable.

1.3.1.6 The programmer/controller shall be 8 bit microprocessor minimally and installed in plug-in standard rack. The rack and pertinent housing shall accommodate the necessary power supplies, timers, attenuators, logic circuits, peak pickers, integrators, and memory units.

1.3.1.7 When the analyzer is used in the stand-alone configuration, the GC shall provide outputs in the form of; analog trends, a serial data link, a printer, alarms, and a strip-chart recorder for set-up and maintenance purposes.

1.3.1.8 A recording system shall be provided in the Gas Chromatograph system to be installed near the programmer unit. The recording system shall provide conventional chromatograms and bargraphs.

1.3.2 Operator's interface

1.3.2.1 The analyzer may be provided with all means necessary to operate the analyzer manually by the operator interface.

1.3.2.2 The analyzer shall have a mounted operator's interface consisting of a keyboard and display to program and monitor the analyzer. The keyboard shall have all function keys and necessary programming and selection keys. The interface shall provide Real-time plots of multi-ramp oven temperature programs and recorded baselines viewing.

1.3.3 Workstation

1.3.3.1 A dedicated PC based workstation shall be provided for the analyzer complete with methods for analyzing, calculating and reporting. The workstation shall use menu-driven program running with MS-DOS or UNIX of higher versions, preferably.

1.3.3.2 The workstation shall create or edit the GC methods and transmit them to the analyzer. In addition, the following checks shall be performed by the workstation:

- Checking the status of the analyzer and monitoring the analysis.
- Storing and managing data.
- Calculations, reporting and data transmission
- Statistical evaluation of results

1.3.3.3 The workstation shall provide enhanced displays on the CRT, as well as log print-outs.

1.3.4 Printer

1.3.4.1 A suitable printer shall be provided with the analyzer for trend and alarm printing.

1.3.4.2 The printer shall be connected to serial port of the PC workstation.

SECTION 2. VISCOSITY ANALYZER

2.1 Applicable Standards

ASTM D445-88	"Test Method for Kinematic Viscosity of Transparent and Opaque Liquids"
ASTM D446-85a	"Specification for Operating Instructions for Glass Capillary Kinematic Viscometers"

2.2 Measuring System

2.2.1 The viscometer shall be of continuous type using capillary U-tube method as specified in ASTM/D445-88 and D 446-85.

2.2.2 The sample shall be pumped through the capillary at a constant flow rate and temperature, and the differential pressure across capillary shall be measured by means of a pressure transmitter as the absolute viscosity of the sample.

2.2.3 The measuring range shall cover maximum range of 0 to 2500 cP by capillary selection range provided complete with the analyzer by the vendor.

2.2.4 The minimum range of the analyzer shall be 0 to 400 centipoise (cP) selectable through use of capillary range tubes.

2.2.5 The precision of the analyzer shall be within $\pm 1\%$ of FSD.

2.2.6 The capillary shall be housed in an easily removable holder which can be removed for cleaning or range changing.

2.2.7 The repeatability of the measurement shall be within $\pm 0.5\%$ of FSD.

2.3 Analyzer Requirements

2.3.1 The viscometer shall be an on-line instrument to generate continuous output signal in linear proportion to the viscosity of the sample.

2.3.2 The viscometer shall be of free-standing type and shall be capable to operate either inside the analyzer house or outdoor under the shelter, as specified in data sheets.

2.3.3 The critical components of the viscometer shall be maintained with constant temperature by being immersed in heated oil bath. The sample temperature shall be kept constant by temperature controller provided in the same enclosure as the analyzer.

2.3.4 A cooling coil shall also be fitted in the mentioned oil bath to carry away the excess heat, if required.

2.3.5 The capillary differential pressure transmitter shall be "integral microprocessor smart transmitter" preferably with local indicator on the transmitter. The smart transmitter shall provide remote; diagnostics, configuration, and interrogation of transmitter in addition to loop integrity test.

2.3.6 The analyzer shall take the sample out of the sample conditioning system and pump it through the capillary at a constant rate.

2.3.7 The output signal of viscometer shall be 4-20 mA dc with electrical zero, span, and suppression capability with local indication.

2.3.8 The continuous response time of the viscometer shall be less than 4 minutes maximally including the sample conditioning time lag.

SECTION 3. BOILING POINT ANALYZER

3.1 Applicable Standards

ASTM D86-82	"Method for Distillation of Petroleum Products"
ASTM D1160-87	"Method for Distillation of Petroleum Products at Reduced Pressure"

3.2 Measuring System

3.2.1 The analyzer shall continuously measure the percent recovered boiling point temperatures of petroleum products from the 5% point to the 97% point in the temperature range of 65°C to 360°C. Alternatively, it shall be possible to measure percent recovered at a given temperature.

3.2.2 The measuring system of the analyzer shall correlate the ASTM-D86 (IP-123), boiling point test method for atmospheric pressure measurements and ANSI/ASTM D1160 for vacuum analysis.

3.2.3 A constant sample flow shall be metered and pumped by diaphragm pumps to the boiler assembly, to be heated by a vertical evaporator element at atmospheric pressure, so that a desired percentage of the sample flow rate is boiled off.

3.2.4 A level controller shall be provided on the remainder collected in the bottom cup, where a constant, selectable percentage of the input sample rate is continuously withdrawn. This controller shall adjust the rate of heat delivered to the sample flowing on the evaporator, so that a constant level of liquid is maintained in the bottom cup.

3.2.5 A thermo-couple shall be provided to measure the temperature of the liquid in the cup. This temperature shall be converted to 4-20 mA signal correlating with the mentioned ASTM boiling temperature determinations method.

3.3 Analyzer Requirements

3.3.1 The BP analyzer shall be an on-line instrument to generate a continuous 4-20 mA output signal with local indication.

3.3.2 The analyzer housing and the components inside the housing shall be mounted on a free-standing welded steel frame made of steel channels. The enclosure width shall not be more than 1800 mm.

3.3.3 The analyzer shall employ microprocessor electronics for operation, control, and checking the functions of the analyzer.

3.3.4 Repeatability of the system shall be within $\pm 1\%$ of the sample actual boiling range.

SECTION 4. FLASH POINT ANALYZER

4.1 Applicable Standards

ASTM D56-87	"Test method for Flash Point by Tag Closed Tester"
ASTM D92-85	"Test Method for Flash and Fire Points by Cleveland Open Cup"
ASTM D93-85	"Test Method for Flash Point by Pensky-Mortens Closed Tester"

4.2 Measuring System

4.2.1 The analyzer shall be an on-line continuous instrument to measure the flash point of petroleum products up to a maximum of 300°C with viscosities up to 2000 c St (at 40°C) at barometric pressure of 760 mm-Hg in accordance with requirements specified in data sheets.

4.2.2 The accuracy and repeatability of the analyzer shall be equal or better than that described in ASTM D93 or ASTM D92 or ASTM D56 as may be applicable (refer to data sheets).

4.2.3 The cooling cycle time of the measurement cycle shall be manually adjustable and shall be of such duration that the liquid thermocouple measured temperature is reduced by approximately 15°C. The maximum reading of this thermocouple shall be used to represent the product flash point.

4.2.4 A DC current shall be imposed across the liquid thermocouple immediately following the ignition to reduce its output emf in a manner to prevent overshoot above the flash point temperature.

4.2.5 The measuring range of the analyzer shall be around 10°C - 121°C.

4.2.6 The response time of the analyzer shall be better than 3 minutes by using a well engineered sample conditioning system, supplied by the analyzer vendor (the typical sample conditioning system is attached to this specification).

4.3 Analyzer Requirements

4.3.1 The analyzer control unit shall contain a transmitter consisting of a high-gain amplifier to translate the temperature element output into a 4-20 mA dc output signal. The transmitter shall have local indication.

4.3.2 The analyzer housing(s) including the components shall be mounted on a free-standing welded steel frame made of steel channels.

4.3.3 All materials in contact with the sample shall be suitable for the fluid being measured.

4.3.4 The analyzer shall be provided with a control unit in separate explosion-proof housing, complete with the power supply, control circuits, and safety interlock circuits.

SECTION 5. POUR POINT ANALYZER

5.1 Applicable Standards

ASTM D97-87 "Test Method for Pour Point of Petroleum Oils"

5.2 Measuring System

5.2.1 By definition made in ASTM D97 (IP-15), the pour point shall be observed in 3°C steps until "solid point" is reached, then 3°C is added to the observed temperature to obtain the indicated pour point.

5.2.2 The measuring system shall apply refrigeration procedure described above and after detection of solid point a signal shall be generated to the instrument control circuit to switch to heating.

5.2.3 The analyzer shall be capable to measure products having viscosities as high as 450°C St at 38°C with pour points down to -50°C.

5.3 Analyzer Requirements

5.3.1 The analyzer shall provide two results per hour minimally and shall be suitable for unattended operation.

5.3.2 All measuring system including; measuring cup, detection system and all provisions for properly flushing the spent sample shall be contained in a separate enclosure. Another separate enclosure shall be provided to contain all the electronics and control circuits for increased safety reasons. A common air purge system shall service to both enclosures.

5.3.3 The electronics of the analyzer shall contain the following safety devices:

- Cooling water temperature alarm,
- sample temperature alarm,
- sample cup high level alarm,
- drain high level alarm,
- pour-point failure protection circuit.

5.3.4 The output signal of the analyzer shall be 4-20 mA dc corresponding to the range of instrument.

5.3.5 The analyzer housings including all components shall be mounted on a free-standing welded steel frame made of steel channels. The enclosure width shall not be more than 1800 mm.

5.3.6 The measuring range of the pour point instrument shall minimally cover -40°C to +40°C.

5.3.7 The analyzer shall provide 4 to 20 mA. Dc output with local indication.

SECTION 6. CLOUD POINT ANALYZER

6.1 Applicable Standards

ASTM D2500-83 "Test Method for Cloud Point of Petroleum Oils" #IP 219

6.2 Measuring System

6.2.1 The measuring system shall consist of; an incandescent lamp to direct light rays, a polarizing film, the sample cell, a second polarizing film, and detecting photo cell, to measure the starting temperature of wax and/or ice crystals formation.

6.2.2 The cloud point measuring system shall precisely correlate the ASTM D2500 standard.

6.2.3 The measuring system shall be capable to measure the cloud point of hydrocarbon streams within the range of -6°C to +25°C using plant cooling water.

6.3 Analyzer Requirements

6.3.1 The analyzer shall be of microprocessor controlled type to control the operation in the following cycles:

1) Flushing or fill cycle:

The test cell shall be flushed with the process sample at the operating temperature for a time between 20 to 45 second.

2) Cooling cycle:

The cell shall be cooled by the cooling module, with the heat being extracted by a cooling water system.

3) Read cycle:

The cloud point shall be detected by the photocell system. This cloud point temperature shall be read and stored. The output signal shall be updated and held at this value until the next read cycle.

6.3.2 Analyzer cycle time shall be between 1 to 4 minute with repeatability better than 1°C.

6.3.3 The analyzer shall be mounted on free-standing framework.

6.3.4 The analyzer shall be capable to communicate with DCS system, in addition to provision of 4-20 mA output signal, if this requirement has been requested through the project data sheet, it shall have local indication as well.

6.3.5 The analyzer vendor shall provide complete sample conditioning system with the analyzer equipment. Attached is a typical sample conditioning system requirement.

SECTION 7. VAPOR PRESSURE ANALYZER

7.1 Applicable Standards

- ASTM D323-82 "Test Method for Vapor Pressure of Petroleum Products (Reid Method)"
ASTM D1267-84 "Test Method for Vapor Pressure of Liquefied Petroleum (LP) Gases (LP-Gas Method)"

7.2 Measuring System

- 7.2.1** The measuring system shall be in accordance with ASTM D323 method or correlate this method precisely for refinery products other than LPG.
- 7.2.2** Vapor pressure measuring system of LPG shall be in accordance with ASTM D1267 or precisely correlate this method.
- 7.2.3** The vapor pressure shall be measured by absolute pressure transmitter (smart type preferably) connected to the sensing device.
- 7.2.4** A back pressure regulator shall be provided for the measuring system to prevent back-flow of the sample and vaporization in the output line.
- 7.2.5** Inlet pressure shall be maintained at a constant value by means of a feed pump or a pressure regulating valve, as may be applicable.
- 7.2.6** Sample temperature shall be controlled by immersing the measuring system and heat exchanger in oil bath equipped with precise PID temperature controller and resistance thermometer.
- 7.2.7** Temperature gradients within the oil bath shall be kept to a minimum by means of suitable agitators.
- 7.2.8** The oil bath shall be provided with heating and cooling medium to take command from the PID temperature controller.

7.3 Analyzer Requirements

- 7.3.1** Analyzer shall be of continuous on-line measuring type.
- 7.3.2** The analyzer shall provide 4-20 mA dc isolated output signal with superimposed digital signal for remote diagnostics, configuration and interrogation of transmitter, in addition to loop integrity tests, preferably. The analyzer shall have local indication as well.
- 7.3.3** The analyzer shall be suitable for continuous measurement of Reid vapor pressure within 60 second response time.
- 7.3.4** All materials in contact with sample shall be constructed of suitable materials such as; stainless steel and teflon (PTFE).
- 7.3.5** The width of the analyzer housing shall not be more than 2500 mm.
- 7.3.6** The analyzer shall provide an Out-of-Service alarm for remote connection to an alarm panel.
- 7.3.7** The analyzer shall be provided with suitable local indicators.
- 7.3.8** The analyzer shall be provided with pneumatic bath lowering device for service purposes. The device shall be pneumatic type, preferably.

SECTION 8. OXYGEN ANALYZER

8.1 Applicable Standards

ASTM D2223-84 "Oxygen Impurity in Nitrogen (Electro Chemical)"

8.2 Measuring System

8.2.1 The measuring system detector shall be electro-chemical or para-magnetic continuous measuring type, or as requested in specific project data sheets, to measure the concentration of oxygen in the sample gas.

8.2.2 The electrochemical sensor cell shall be of sealed electrochemical type to be maintenance-free with no electrolyte to change or electrodes to clean.

8.2.3 The measuring system shall produce an output in linear proportion to oxygen concentration.

8.2.4 The measuring system shall correlate the results according to ASTM D2223.

8.3 Analyzer Requirements

8.3.1 The analyzer shall be rugged, percent oxygen (O₂) analyzer to provide reliable on-line monitoring of oxygen in sample gas.

8.3.2 The analyzer shall provide full scale measuring ranges from 0-1% up to 0-100% volumetrically.

8.3.3 The analyzer shall have current output of 4-20 mA dc with additional two SPDT contact outputs for alarm settings, it shall have local indication as well.

8.3.4 The sensitivity of the analyzer shall be within 0.5% of full scale.

8.3.5 The local meter read-out accuracy of the analyzer shall be within 2% of full scale at ambient temperature.

8.3.6 The overall accuracy of the analyzer shall be better than 5% of full scale of the instrument.

8.3.7 All materials in contact with sample shall be selected of resistant materials unaffected by oxidizable gases. All tubings shall be made by means of stainless steel.

8.4 Calibration Facilities

8.4.1 Vendor shall provide all equipment and calibration gases necessary for on-line calibration of the analyzer.

8.4.2 The calibration system shall be of wall mounted type to be installed on outside wall of the analyzer house.

8.5 Interconnecting Cables

8.5.1 Vendor shall supply all interconnecting cables between sensor and analyzer control unit, as specified in data sheets.

8.6 Portable Analyzer Requirements

8.6.1 An indicating oxygen analyzer shall be provided complete with sampling system assembled in a weatherproof housing for field mounting, where portable analyzer is specified in data sheets.

8.6.2 The sampling system shall be complete with reducing regulator, pressure and vacuum protection, condenser, filter-moisture separator, winter heating coil, flowmeter, etc., completely assembled in a field mounting cabinet housing.

SECTION 9. DENSITY AND SPECIFIC GRAVITY ANALYZER

9.1 Applicable Standards

ASTM D70-82	"Test method for Specific Gravity of Semi-Solid Bituminous Materials"
ASTM D941-88	"Density and Relative Density of Liquids by Lipkin Bicapillary Pycnometer"
ASTM D1070-85	"Test Methods for Relative Density (Specific Gravity) of Gaseous Fuels"
ASTM D1217-81	"Density and Relative Density by Bingham Pycnometer"
ASTM D1298-85	"Density, Relative Density, or API Gravity of Crude Petroleum Products by Hydrometer Method"
ASTM D1657-83	"Specific Gravity of Light Hydrocarbons by Pressure Hydrometer"
ASTM D3142-84	"Specific Gravity or API Gravity of Liquid Asphalt by Hydrometer Method"
ASTM D3289-85	"Test Method for Specific Gravity or Density of Semi-Solid Bituminous Materials by Nickel Crucible"

9.2 Measuring System

9.2.1 The measuring system shall be suitable for continuous measurement of samples in accordance with one of the above mentioned standard laboratory test methods, as specified in data sheets.

9.2.2 Density and specific gravity measurement system of analyzers used for gaseous services shall be based on ASTM D1070-85 Standard.

9.2.3 Density and specific gravity measurement system of analyzers used for cryogenic fluids shall be based on the vibrating spool principle.

9.2.4 Density or specific gravity measurement system of analyzers used for measuring percent of solids content of slurries shall be based on vibrating tube principle.

9.2.5 Radiation absorption measurement system shall be used for applications involving process streams that are highly corrosive or difficult to handle or toxic and dangerous to personnel.

9.2.6 In gas density measurements, where high sensitivity and rangeability is required, the analyzer measuring system shall be based on turbojet principle.

9.2.7 For details of operating principles mentioned herein, reference may be made to API-RP 550, Part II, Section 8.

9.2.8 Specific gravity measurement for the refinery products shall be based on ASTM D1298 principle.

9.3 Analyzer Requirements

9.3.1 The measuring system and the electronic components shall be housed in two different suitable enclosures. The analyzer shall perform continuous unattended determination of specific gravity.

9.3.2 The analyzer electronics shall be microprocessor based type.

9.3.3 The output signal of the analyzer shall be 4-20 mA dc for stand-alone instrument. The output shall be suitable for remote recording and calculation of mass flow. The analyzer shall have local indication as well.

SECTION 10. H₂S AND TOTAL SULFUR ANALYZER

10.1 Applicable Standards

ASTM D1072-80	"Total Sulfur in Fuel Gases"
ASTM D1266-87	"Sulfur in Petroleum Products by the Lamp Method"
ASTM D2420-86	"H ₂ S in LPG by the Lead Acetate Method"
ASTM D2622-87	"Sulfur in Petroleum Products by X-Ray Spectrometry"
ASTM D3031-81	"Total Sulfur in Natural Gas by Hydrogenation Method"
ASTM D3227-83	"Mercaptan Sulfur in Gasoline and Distillate Fuels by Potentiometric Titration"
ASTM D4084-82	"H ₂ S in Gaseous Fuels by Lead Acetate and Reaction Rate"
ASTM E840-81	"Practice for using Flame Photometric Detectors in Gas Chromatography"
ASTM D1552	"Sulfur in Petroleum Products by High Temperature Method"
ASTM D129-64	"Sulfur in Petroleum Products by General Bomb Method"

10.2 Measurement Systems

10.2.1 Gas chromatography with FPD

10.2.1.1 For details of Sulfur-Specific Flame Photometric Detector basic principles of chromatography, reference shall be made to Section 1.0.

10.2.1.2 The measuring system proposed shall comply with ASTM-E840 and shall correlate the results according to ASTM D1072 for fuel gases or D3031 for natural gas.

10.2.2 Lead acetate paper tape staining analyzer

10.2.2.1 This type of measuring system shall comply with ASTM D 2420 for measurement of H₂S in LPG, ASTM-D4084 for gaseous fuels in the range of 0.1-16 ppm.

10.2.2.2 This type of measurement may be proposed for ambient air monitoring (preference will be given to solid state sensors for ambient monitoring).

10.2.3 Titrometric/absorption and conductivity measurement analyzer

10.2.3.1 Titrometric measuring system shall comply with ASTM-D3227 for measurement of mercaptan sulfur in distillate fuels.

10.2.3.2 This type of measurement system shall be proposed for analyzers measuring mercaptan sulfur in gasoline, kerosene, jet fuel and other distillate fuels within the range of 0.0003 to 0.10 Wt%.

10.2.3.3 The measuring system shall perform continuous measurement of mercaptan sulfur, using either instrument air or Nitrogen as sulfur-free zero adjustment.

10.2.3.4 The reaction solution used to detect the mercaptan sulfur compounds, shall be of inexpensive commercially available inorganic materials.

10.3 Analyzer Requirements

10.3.1 Gas chromatography with FPD

10.3.1.1 The Gas Chromatograph shall be generally similar to that specified in Section 1.0 with exception of the detector which shall be Flame Photometric Detector (FPD) type. Detector shall burn the sulfur containing of the sample in a hydrogen flame to produce elemental sulfur and gather the emitted light and transmit the light through a narrow band-

pass filter (394 nm) onto a photo-multiplier sensor. The gathering and transmission of the light shall be performed by a fiber-optic bundle preferably.

10.3.1.2 The FPD/GC shall have it's own microprocessor circuit to control the FPD measuring system.

10.3.1.3 All other requirements set-forth in section 1.0 shall be fulfilled for this type of analyzer as well.

10.3.1.4 The response time shall be better than 5 seconds.

10.3.2 Lead acetate paper tape staining analyzer

10.3.2.1 The lead acetate paper tape analyzer shall be continuous measuring instrument for on-line trace measurement of H₂S in process gases within the range 0-2 up to 0-100 ppm.

10.3.2.2 The vendor shall propose the most suitable range according to the project data sheets.

10.3.2.3 The analyzer shall be provided with a solid-state Hold amplifier to provide a 4-20 mA dc output signal proportional to the H₂S concentration in the sample gas, linearly.

10.3.2.4 The sample shall enter the instrument with precisely controlled flow rate.

10.3.2.5 Tape movement shall be accomplished by a precision synchronous motor.

10.3.2.6 A soft-seating pressure bar shall be provided for positive tape seal against the reaction window.

10.3.3 Titrimetric/absorption and conductivity analyzer

10.3.3.1 The analyzer shall be continuous on-line type to measure trace mercaptan sulfur in gaseous process streams.

10.3.3.2 The analyzer shall be provided with suitable solid-state electronic unit to provide 4-20 mA dc output signal in linear proportion to the sample gas total mercaptan sulfur concentration. The analyzer shall have local indication as well.

10.3.3.3 The analyzer shall be made of two enclosures, one titration measuring enclosure of air purged type design, and another explosionproof enclosure for control unit housing.

10.4 Sampling and Sample Conditioning System

10.4.1 FPD gas chromatograph

The sample conditioning system shall be similar to those provided for Gas Chromatographs, in Section 1.0

10.4.2 Other type of analyzers

Analyzer vendor shall propose the most suitable sample conditioning system to be further evaluated by the Company, a typical sample conditioning system is attached hereto.

SECTION 11. SPECTROMETRIC ANALYZERS

11.1 Applicable Standards

ASTM-D156-87	"Saybolt Color of Petroleum Products (Saybolt Chromometer Method)"
ASTM-D1500-87	"ASTM Color of Petroleum Products (ASTM Color Scale)"
ASTM-D2392-85	"Test Method for Color of Dyed Aviation Gasolines"

11.2 Application

11.2.1 On-line process analyzers using spectrometric techniques may be proposed for selective measurement of the concentration of one or more components primarily in the gaseous phase. Reference may be made to API, RP 550, Part II, Section 3.

11.2.2 IR/absorption technique analyzer may be used for measurement of moisture in solids.

11.2.3 UV/visible and IR absorption spectrometers may be used for water quality monitoring. This type of analyzer shall be used to monitor opacity (turbidity) or color of process liquids, etc.

11.3 Measurement System

11.3.1 Non-Dispersive Infra-Red (NDIR) analyzers

11.3.1.1 The measuring system shall be made of dual beam infra-red source and Luft-type detector, which will be filled with the component to be analyzed.

11.3.1.2 Absorption of IR radiation by the sample molecules shall result the detector imbalance to be sensed as a change in capacitance and transduced by an electronic unit to 4-20 mA output corresponding to component concentration in the sample.

11.3.1.3 The analyzer shall be equipped with suitable narrow bandpass filters enabling to select only the wave-lengths of interest from the source of radiation. Filter cells shall also be added to remove undesirable wavelengths from both sample and reference beams.

11.3.1.4 The analyzer optical path shall not have any exposure to ambient air.

11.3.1.5 Internal calibration shall be provided by an optical wedge in a manner to provide full-scale signal with zero gas in the sample cell.

11.3.1.6 The analyzer system shall be sensitized to the material to be analyzed, as specified in project data sheets.

11.3.2 Ultraviolet/visible analyzer

11.3.2.1 This type of analyzer shall generally operate on the same basic principles as process IR analyzers except that the source and detector are designed specifically for the wave-length within the ultraviolet/visible portions of the electromagnetic energy spectrum.

11.3.2.2 Sample shall flow continuously through the sample cell, absorbing energy at various wavelengths in accordance with its composition. The analyzer shall monitor at least two of those wavelengths, one of which shall be the wavelength where the component of interest has a characteristic spectral peak, and the other a reference wavelength.

11.3.2.3 For color monitoring applications, including; petroleum products, edible oils, and waste water, the analyzer shall be calibrated to correlate the laboratory standards, such as ASTM D156, D1500, or D2392, according to the requirements specified in data sheets.

11.3.3 Opacity/color analyzer

11.3.3.1 The measuring system shall be based on a cell in which a visible light beam (IR components removed by a primary filter) is modified and passed through the sample stream. Changes from a present level of color or opacity shall be detected by a photo-cell to infer the degree of light modification according to ASTM D156 or D1500 color ranges.

11.3.3.2 UV/visible analyzer in the visible region may be used for applications where the color intensity of a product, or the lack of it, is important and shall be measured accordingly.

11.3.3.3 A self resetting Twist-to-Test externally mounted spring loaded knob shall be provided for the unit enabling the light beams to be unbalanced in order to test the system.

11.4 Analyzer Requirements

11.4.1 Spectrometers and photometers

11.4.1.1 The analyzer shall be continuous, on-line instrument to measure the concentration of all gases specified in project data sheets in both liquid and gas samples.

11.4.1.2 Measurement ranges from 500 ppm to 100% for various gases down to a range of 0-5 ppm shall be provided by the instrument to suit the particular application as specified in the project data sheets.

11.4.1.3 The analyzer shall provide a 4-20 mA dc current output for remote applications. The analyzer shall have local indication as well.

11.4.1.4 The analyzer shall be suitable for measurement of process gases or liquids.

11.4.1.5 The analyzer shall be of free-standing or wall-mounting type as approved by Company's engineering body in charge of the project. The analyzer equipment shall be housed in a two compartment enclosure, the first one containing the analysis unit, and the other for housing electronic control units.

11.4.1.6 Drift of the measurement shall be less than 1% per day.

11.4.1.7 Accuracy and reproducibility of the analyzer shall be better than $\pm 2\%$ of full scale.

11.4.1.8 Single stream spectrometer analyzers control unit shall be solid state type with 4-20 mA dc analog output signal plus alarm relays which can directly operate valves or equipment for totally automated process control.

11.4.1.9 The analyzers shall be inherently stable, meaning that; compensation for lamp aging, window deposits, and turbidity to be performed automatically.

11.4.2 Photometric alarms (opacity/color analyzer)

11.4.2.1 Changes from a preset level of color or opacity, which can be inferred from the degree of light modification, shall be measured by means of photo-cell with electronic circuitry working in conjunction with a light source. The photo-cell with pertinent electronic circuitry shall actuate an alarm relay if the sample conditions goes out of limits.

11.4.2.2 The system shall incorporate also "Failure Alarm" facility in addition to selectable high/low alarms, all rated at 110 V/5 A.

11.4.2.3 The photometric alarm shall have 1/4" NPT(F) sample connection.

11.4.2.4 Internally mounted control knobs shall be provided for setting the alarm levels.

11.4.2.5 The unit shall have 4-20 mA dc analog signal to infer the color or opacity of the sample continuously. The instrument shall have local indication as well.

11.5 Safety Requirements

11.5.1 The measuring system enclosure shall be of purged type, as specified in Part 3 Article 3.2.1.

11.5.2 The electronic control unit enclosure shall be explosionproof type certified for application in the related classified area by UL or other approval bodies.

11.5.3 The CRT terminal enclosure may be of general purpose type.

11.5.4 The photometric alarm equipment shall be certified by authorized agencies for EExd, II B, T6 according to CENELEC EN 50.018 'd' for Zone 1 areas or for corresponding American area classification.

SECTION 12. MOISTURE ANALYZER

12.1 Applicable Standards

ASTM-D95-83	"Water in Petroleum Products by Distillation"
ASTM-D1142-86	"Water Vapor Content of Gaseous Fuels by Dew-Point measurement"
ASTM-D1744-83	"Water in Liquid Petroleum Products by Karl-Fischer Titration"
ASTM-D1796-83	"Water and Sediment in Fuel Oils by Centrifuge Method"
ASTM-D4006-81	"Water in Crude Oil by Distillation"
ASTM-E203-75	"Karl-Fischer Test Method"
ASTM-E700-79	"Water in Gases by Karl-Fischer Test Method"

12.2 Moisture Measurement System

12.2.1 Automated Karl-Fischer system

12.2.1.1 Basically this type of measuring system shall be based on ASTM D1744 Standard or other Standards in Article 13.1, as specified in data sheets.

12.2.1.2 This technique of measurement may be applied in gas pipeline applications, as well.

12.2.2 Dew-point measurement by mirror-type instruments (optical/condensation type)

12.2.2.1 Mirror-type instrument shall be proposed for dew-point measurement of gaseous samples with dew point less than atmospheric temperature. The analyzer shall correlate the results according to ASTM D1142 Standard.

12.2.2.2 The measuring system shall consist of a mirror which its temperature is adjusted automatically to the dew-point of the sample gas to be measured.

12.2.2.3 In this method of moisture analysis a beam of light shall be reflected from the gold-surfaced peltier element-cooled mirror and the intensity shall be measured by a photocell. A second photocell shall monitor the light source directly. The difference between the two signals represents the size of the dew spot on the mirror. Electronic circuits shall maintain the difference in phototube outputs at a preset value by varying the amount of power to a heating coil. By controlling mirror temperature and the subsequent size of the dew spot, equilibrium shall be maintained. The mirror temperature shall be measured and recorded directly by a precision platinum RTD embedded in the mirror as the dew-point of the gas. The analyzer system shall comply with ASTM D1142 Standard.

12.2.3 Capacitance type measurement

12.2.3.1 Capacitance type measurement system shall be proposed for applications encountering wide range of water concentration in liquid or gaseous samples (i.e. 1 ppm up to 60%), such as; propane, butane, benzene, gasoline and kerosene, as well as gas streams, such as; hydrogen, natural gas, nitrogen, and air, according to project data sheets.

12.2.3.2 Capacitance-type measuring system shall employ a capacitance cell with a desiccant filling the space between the electrode plates to serve as the dielectric in the capacitance cell. Any small change in the water content of the sample shall cause a large change in the capacitance and shall be electrically detected and amplified to correlate the moisture content of the sample.

12.2.3.3 The system shall be capable to be calibrated in ranges from 1 to 1000 ppm of moisture for gaseous samples. For liquid samples, the analyzer shall measure moistures from 5 to 60 percent of the solubility of water in the liquids. The system shall correlate the results of ASTM D95 or D1796 as specified in data sheets.

12.2.3.4 The measuring system shall comprise of an isolated temperature controlled block, housing the moisture cell, with precise temperature controller.

12.2.4 Vibrating crystal measuring system

12.2.4.1 This type of measuring system should measure the moisture content by comparing the changes in frequency of two hygroscopically coated quartz crystal oscillators which in dry phase will vibrate at a predetermined frequency.

The water vapor shall be alternately absorbed and desorbed on the measurement crystals, resulting in a mass difference with a corresponding change in frequency, which shall be compared electronically, and the moisture content shall be indicated in ppm by volume or percent as required in data sheets.

12.2.4.2 The analyzer shall be capable to be calibrated to measure ranges from 0 to 5 ppm up to 0 to 25'000 ppm, full scale. The analyzer shall correlate the results of ASTM D95 or D1796, as specified in data sheets.

12.2.4.3 A flow switching system shall be provided to expose alternately one crystal to the moist sample gas and then to a dry reference gas every 30 seconds. The second crystal shall be kept dry and used as a reference.

12.3 Analyzer Requirements

12.3.1 General requirements

12.3.1.1 The analyzer electronics shall be made of plug-in solid state electronic circuit boards for easy remove, check, adjust, and replace.

12.3.1.2 The electronics employed shall be of solid-state technology. Application of microprocessors to perform the necessary controls and communicate to the plant DCS shall be considered. The microprocessor shall provide user friendly diagnostics of the analyzer system.

12.3.1.3 The analyzer shall consist of two separate enclosures; one to house the measuring system to be field mounted near the process, and the other housing for electronics to be; analyzer house or control room mounted type, as specified in data sheets.

12.3.1.4 All analyzers shall be equipped with High/Low alarm module.

12.3.1.5 Analyzer output signal shall be considered to be 4-20 mA dc.

12.3.2 Karl-Fischer analyzer

12.3.2.1 This type of moisture titrator shall be automated instrument based on Karl-Fischer titration method.

12.3.2.2 This type of moisture titrator shall be used primarily in natural gas pipeline applications, where 20 to 40 barg pipeline pressure can be used as the pump operating medium.

12.3.2.3 The analyzer system shall have the range of 15-1600 kg/MM m³ moisture concentration.

12.3.2.4 The analyzer repeatability shall be within $\pm 3\%$ of the reading.

12.3.2.5 The analyzer shall be capable to compute and indicate the moisture concentration in the customer selectable units (e.g., ppm, kg/MM m³, Lb/MMSCF).

12.3.3 Mirror-type dew-point analyzer (optical/condensation type)

12.3.3.1 The dew-point humidity analyzer shall be microprocessor based system, designed to provide continuous, accurate dew-point measurement over the range of -70°C to +60°C, or equivalent ranges of other parameters, such as; RH, ppm moisture, and so on.

12.3.3.2 The output signal of the analyzer shall be PT-100, BCD or 4-20 mA dc, user selectable.

12.3.3.3 The sensor assembly shall be remote mounted type with permissible distance from the control unit.

12.3.3.4 The dew-point sensor shall be of improved compensation type for contamination build-up on the mirror surface by using two reflective mirrors in physical and thermal proximity to each other as "wet" and "dry" mirrors.

12.3.3.5 Two LED light sources shall be employed, with switching circuit to allow one photo-transistor to be used without mixing the two light signals. A continuous balance control system shall be employed to verify the sensor performance and correct for contaminant build-up without the loss of real time data.

12.3.3.6 An alarm signal shall be generated to indicate that mirror cleaning is required, when the sensor approaches contaminant levels above which it can no longer be compensated.

12.3.4 Capacitance type analyzer

12.3.4.1 The analyzer shall be continuous on-line type instrument, providing fully-automatic scanning of 8 sensors minimally with an individual sensitivity control for each channel and push-button switches for channel selection.

12.3.4.2 The sensing probe shall consist of a metal core, coated with a hygroscopic dielectric material and finally covered with a porous gold film acting as a variable capacitor sensitive to moisture of gases. Different probes shall be provided to cover the dew-point range of -80°C to 56°C preferably in the following ranges:

-80°C to -20°C
-60°C to 0°C
-50°C to 56°C
-30°C to 56°C

12.3.4.3 The instrument shall provide 4-20 mA dc signal with local indication.

12.3.5 Vibrating crystal analyzer

12.3.5.1 The analyzer shall be; on-line, continuous type moisture measuring system.

12.3.5.2 The analyzer system shall consist of separate measuring unit enclosure to be locally mounted and a control unit enclosure suitable to be mounted in analyzer house or control room, as specified in data sheets.

12.3.5.3 The control system of the analyzer shall be microprocessor based electronic type.

12.3.5.4 Both measurement and local oscillator crystals shall be temperature controlled at 60°C for optimum repeatability and accuracy.

12.3.5.5 The instrument range shall be user selectable and shall have 4-20 mA dc analog output signal with local indication.

12.3.5.6 An internal moisture calibrator shall be fitted in the analyzer system consisting of a temperature-controlled water reservoir and a permeation tube of suitable resin.

SECTION 13. COMBUSTIBLE GAS DETECTION ANALYZER

13.1 Measuring System

13.1.1 The sensor shall operate on catalytic principle and shall consist of two detector elements; one element sensitive and the other insensitive to flammable (combustible) gases.

13.1.2 The sensor element shall form the arms of a resistance bridge network connected to the control unit.

13.1.3 The elements shall be heated to the operating temperature, by an electrical current supplied from the control unit, to perform oxidation when flammable gases are present at the sensor proximity.

13.1.4 The flammable gas oxidation shall take place at the sensitive element, raising its temperature and hence its electrical resistance. The resulting bridge unbalance shall generate a voltage proportional to the flammable gas concentration at the sensor. The voltage shall be used by the control unit to indicate gas concentration.

13.1.5 Solid state semi-conductor type sensors may be proposed if it is strictly sensitive to the combustible gases and not to other gases present in the atmosphere.

13.2 Analyzer Requirements

13.2.1 The analyzer shall be suitable for on-line continuous measurement of combustible gases.

13.2.2 The system shall have the capability of remote multi-sensors connections from satellite stations.

13.2.3 The control unit of the analyzer shall basically consist of an assembly of the following component modules, mounted in a freestanding cabinet:

- Sensor modules (one per sensor, field mounted type)
- Processor module with pertinent accessories as mentioned in 14.2.2.
- Scanner modules
- Sensor power supply modules.

13.2.4 The analyzer shall be capable to be connected to the plant DCS and computer system, if specified in the project data sheets.

13.2.5 The combustible gas sensor transmitters, for multi-channel measurement, shall be identical in design and shall be normally calibrated 0-100% LEL, and shall have a common meter module to provide; indication, reset switching, and functional checking as well as span and zero controls.

SECTION 14. NITROGEN OXIDES MEASUREMENT ANALYZER

14.1 Applicable Standards

ASTM D1607-88	"NO ₂ by Griess-Saltzman Reaction"
ASTM D3608-89	"Total Nitrogen Oxides (NO _x) Content of the Atmosphere by Griess-Saltzman Reaction"

14.2 Measurement System

14.2.1 The measuring system shall operate on chemiluminescence detection technique complying with ASTM D1607 and ASTM D3608 standards to detect NO concentration.

14.2.2 For the measurement of NO_x (total NO + NO₂), the sample shall be passed through a NO₂-to-NO converter prior to reaction with Ozone and emitting of light consequently. The NO₂ concentration shall be calculated as difference of the total NO_x and the primary measured NO concentration.

14.2.3 Ambient air shall be used by the analyzer for Ozone generation by means of a pump and a ultra-violet lamp.

14.2.4 A controlled flow rate of ozonized air shall be directed to the reactor for reaction with NO present in the sample.

14.2.5 After reaction of sample with ozonized air, the gases shall be vented to the atmosphere.

14.2.6 The calibration shall be performed by selection of the "Mode switch" to actuate associated three way solenoid valve letting; either a span gas to be directed to the reaction chamber or shutting off the flow of ozonized air to the reactor for zero check.

14.2.7 A three-way solenoid valve shall be provided down-stream of the converter to be switched automatically permitting NO analysis when by-passing the converter, and NO_x analysis when sample being passed through the converter.

14.2.8 The NO to NO_x converter shall be of heated temperature-controlled carbon base, free of interference from all atmospheric gases including ammonia, sulfur compounds, water and hydrocarbons.

14.2.9 Sample and Ozone flowrates shall be controlled by the use of capillaries.

14.2.10 Light emission radiated by chemiluminescent reaction shall be detected by photo-multiplier with thermostatically cooling for zero stability and minimum "dark current".

14.2.11 The reaction chamber shall operate at atmospheric pressure.

14.3 Analyzer Requirements

14.3.1 The analyzer shall provide on-line analysis and continuous analog voltage outputs for all three parameters, (i.e., NO_x, NO, and NO₂).

14.3.2 The analyzer design and construction shall be suitable for heavy-duty engine, turbine, and stationary (stack) source monitoring applications as specified in data sheets.

14.3.3 Analyzer electronics shall be all solid state with integrated circuits and plug-in circuit boards suitable for easy removal and replacement. Test points shall be provided for easy checking of all operations.

14.3.4 The current from the photomultiplier tube shall be measured by a high input impedance amplifier, such as integrated circuit MOSFET amplifiers.

14.3.5 The analyzer electronics shall include a timer for automatic cycling between NO and NO_x modes and the signal difference shall be electronically determined to provide a direct NO₂ reading output.

14.3.6 Continuous outputs of 1 to 5 Volt shall be made available for recording, telemetry, etc. of each parameter (NO, NO_x and NO₂).

14.3.7 At least seven instrument ranges shall be available via a selector switch (0-0.25, 0-0.5, 0-1.0, 0-2.5, 0-5, 0-10.0 and 0-25 ppm)

14.3.8 Zero drift shall be less than 1% per day and 2% per three days.

14.3.9 Span drift shall be less than 1% per day and 2% per three days non-cumulative.

14.3.10 Minimum detectable sensitivity of the analyzer shall be 0.005 ppm on the lowest range.

SECTION 15. SULFUR DIOXIDE ANALYZER

15.1 Applicable Standards

ASTM D2010-85	"Total Sulfation in the Atmosphere by Lead Peroxide Candle"
ASTM D2650-83	"Gas Mixtures by Mass Spectrometry"
ASTM D2914-78	"Sulfur Dioxide Content of the Atmosphere by the West-Gaeke Method"

15.2 Measuring System

15.2.1 The analyzer shall be of UV, absorption type, spectrometer, preferably.

15.2.2 The spectrometer shall be equipped with a reference filter to eliminate interference from other gases. Thus the measurement provided by this analyzer shall be specific to SO₂ and unaffected by the presence of other components of a typical stack gas, or atmosphere.

15.3 Analyzer Requirements

15.3.1 Analyzer system shall be suitable for continuous monitoring and controlling of the SO₂ in the stack gas or SO₂ scrubber.

15.3.2 The light source of the analyzer shall be of quartz-deuterium lamp, preferably.

15.3.3 A blue-sensitive photomultiplier detector shall be provided for the analyzer to measure the resulting SO₂ fluorescence.

15.3.4 The analyzer shall consist of three interconnecting modules. The source module containing a deuterium arc lamp which emits radiation in the range 200-400 nm. The second module shall consist of a quartz lens focusing the lamp radiation through a temperature controlled sample cell. After passing through the sample cell, lamp energy shall be chopped by a rotating filter disc in the detector module (third module) which contains the measurement and reference filters as well.

The detector modulated output shall be processed by the electronic circuitry to produce a linearly proportional output to the SO₂ concentration in the sample.

15.3.5 The analyzer shall be provided with an automatic electronic zero mode to be activated once each hour automatically, allowing zero gas to be introduced into the analyzer system and the analyzer output to be adjusted to zero automatically.

15.3.6 Accuracy, reproducibility, and linearity of the analyzer shall be within $\pm 1\%$ of the full scale.

15.3.7 The analyzer shall be of free standing rack-mounted type and shall be equipped with required interfacing with data processing equipment in addition to the 4-20 mA output signal with local indication.

15.4 Sample Handling/Conditioning System

15.4.1 The SO₂ analyzer shall be complete, fully-integrated system that provides extractive-type sample handling and conditioning.

15.4.2 The sample shall be drawn from the stack through a specially designed filter probe provided by the analyzer vendor for removing entrained particulates.

15.4.3 Heat-tracing of the sampling system and effective control of sample temperature shall be provided to prevent water condensation and resultant SO₂ loss during analysis.

15.4.4 To preserve accuracy of the analysis, the sample shall be adjusted to a constant pressure in the temperature controlled sample cell by the sample conditioning system.

15.4.5 The sample conditioning system shall include a manual selector valve for introduction of a span gas to be used for calibration purpose.

15.4.6 During the automatic zero cycle, the zero gas shall flow back through the probe, providing a backflush of the probe.

15.4.7 All wetted parts shall be coated with Teflon or other resistant materials to SO₂.

SECTION 16. CARBON MONOXIDE ANALYZER

16.1 Applicable Standard

ASTM D3669-78 "Carbon Monoxide Content of the Atmosphere by the Manual Turbidometric Method"

16.2 Measuring System

16.2.1 The CO analyzer shall operate on Non-Dispersive Infra-Red (NDIR) spectrography system as described in Section 12.

16.2.2 The system shall consist of a NDIR spectrometer, an automatic zero/span module, flowing reference panel, and sample handling module combined in a single system.

16.2.3 The analyzer sample cell shall continuously receive the sample containing CO, while the reference cell receives the sample which has passed through a CO-CO₂ converter. A differential measurement of IR energy absorption between the two cells shall be performed to produce an accurate measurement of CO concentration.

16.3 Analyzer Requirements

16.3.1 The analyzer shall perform continuous, on-line measurement of CO concentration in the atmosphere.

16.3.2 The analyzer shall be provided with electronic timer for automatic standardization of zero and span in the intervals as recommended by manufacturer. The output read-out shall be corrected to the appropriate zero/span value.

16.3.3 The analyzer output signal shall be 4-20 mA dc.

16.3.4 The analyzer range shall be within 0-5 ppm with a precision within 0.2 ppm.

SECTION 17. AMMONIA MEASUREMENT ANALYZER**17.1 Measuring Systems**

17.1.1 Infra-Red (IR) absorption technique shall be proposed for Ammonia measurement.

17.2 Other Requirements

17.2.1 IR analyzers used for Ammonia measurement shall meet all requirements set forth in Section 11.

SECTION 18. CHLORINE AND HYDROGEN CHLORIDE ANALYZER

18.1 Measuring System

18.1.1 The measuring system shall be of electrochemical sensor probe type.

18.1.2 The measuring probe shall be suitable to measure HCl, Br₂, HBr, HF, BCl₃, SiCl₄, and any other gas that hydrolyse into HF or HCl.

18.1.3 The probe shall be available in 0-2, 0-5, 0-10, 0-20 ppm measuring range.

18.1.4 The probe repeatability shall be within $\pm 1\%$.

18.1.5 The probe stability of measurement shall be $\pm 1\%$ of full scale in 30 days period with speed of response of 0.3 seconds to alarm level (1 ppm).

18.1.6 The probe shall be suitable to be fixed to 2 inches pipe hanger. The probe shall be capable to accept a ½" tube connector for application of monitoring inside the ducts or tanks.

The current generated by electrolysis reaction in the sensor shall be amplified and transmitted by the probe as a voltage signal to the analyzer or to the local multiplexer for multi-point systems.

18.2 Analyzer Requirements

18.2.1 The local multiplexer system of the analyzer shall be microprocessor based and shall be capable to accept minimally 10 probes individually.

18.2.2 The local multiplexer enclosure shall be suitable for field mounting and shall meet the requirements of the area as has been requested through the project data sheet.

18.2.3 The output signal of the analyzer shall be 4-20 mA dc.

SECTION 19. PH AND REDOX ANALYZER

19.1 Applicable Standards

IEC 746	"Expression of Performance of Electro-Chemical Analyzers"
746-1(1982) Part 1:	"General"
746-2(1982) Part 2:	"pH Value"
ASTM D1293-84	"Hydrogen Ion Measurement (pH)"
ASTM D1498-76	"Oxidation-Reduction (REDOX) Potential"

19.2 Measuring System

19.2.1 The measuring system shall consist of two separate probes (electrodes), a reference electrode and a measuring electrode. The electrodes shall be connected to the analyzer by means of a field mounted transmitter.

19.2.2 The reference electrode shall be mechanically unbreakable and shall be resistant to coating or chemical attack. Reference electrode design shall be in a manner, not requiring electrolyte replenishment or any external pressurization and shall be constructed without a flowing electrolyte junction preferably. The electrode shall include a silver/silver chloride half cell immersed in saturated kcl (salt bridge).

19.2.3 In applications where provision of the above mentioned reference electrodes are not possible, then flowing junction reference electrodes may be provided, suitable for the application encountered.

19.2.4 The measuring electrode for pH or REDOX measurement shall be equipped with thermocompensators for automatic temperature compensation and shall be provided in one of the following types according to the specific application:

- Low-resistance type for general measurements
- High-temperature type with low sodium-ion error.
- Gold or platinum electrode type for REDOX measurements.

19.2.5 Electrode mounting assemblies shall be provided with the system. Analyzer vendor shall propose the best suited mounting method for the application involved among one of the following types:

- flow through chambers;
- submersion assembly;
- in-situ type.

19.2.6 The mounting assemblies of pH measuring electrodes shall be constructed of 316 stainless steel unless other corrosion-resistant materials are required for the specific application.

19.2.7 Flow-through and submersion assemblies made of 316 stainless steel shall be fitted with an ultrasonic electrode cleaning system. An ultrasonic transducer shall be mounted directly to the electrode assembly and shall be connected to an electronic exciter unit, housed in an explosion-proof enclosure. The exciter unit shall provide an nominal output of 40 kHz to drive the transducer with an adjustable 15 minute timer to drive the ultrasonic exciter on and off periodically.

19.2.8 The electrodes shall transmit the pH or REDOX measurement to the analyzer system by means of a two wire PH transmitter. The transmitter output shall be 4-20 mA dc.

19.2.9 The REDOX half-cell shall be combined with a standard reference electrode, such as the silver/silver chloride to measure the Oxidation-Reduction potential accurately in the same way as pH measurement.

19.3 Analyzer Requirements

19.3.1 The PH/REDOX monitor/controller shall be preferably a microprocessor-based unit providing accurate temperature compensation and analyzer output shall be 4-20 mA. dc. complete with local indication.

19.3.2 The analyzer shall be capable to display temperature at the electrodes, to be used during calibration or evaluating process conditions.

19.3.3 The analyzer shall have a digital read-out with at least six digit indication (0.00 to 14.00 pH or -1400 to +1400 mV REDOX) in the display module.

19.3.4 The analyzer shall have dual alarm capability with alarm setpoint programmable from the keyboard of the analyzer and adjustable over the full range.

SECTION 20. CONDUCTIVITY ANALYZER

20.1 Applicable Standards

IEC 746-1 (1982) Part 1:	"General"
IEC 746-3 (1985) Part 3:	"Electrolytic Conductivity"
ASTM D1125-82	"Conductivity and Resistivity of Water"

20.2 Measuring System

20.2.1 Measuring system shall be proposed in accordance with the application, from one of the following types:

- electrode with direct reading meter measuring circuit;
- electrodeless induction type with direct reading meter measuring circuit.

20.2.2 The electrodeless conductivity cell shall be either dip-type or flow-through design according to the specific application.

20.2.3 The materials selected for electrodes or conductivity cells shall be suitable for the process fluid encountered.

20.2.4 For steam purity analysis, vendor shall provide Larson-Lane type measuring system. In this type of measuring system, the steam shall be condensed in a water cooled condensing chamber and volatile gases vented. The steam condensate then shall pass through the first of two conductivity cells and down to a cation exchange chamber. The second cell shall measure the conductivity of the final effluent (dissolved gas sample). The conductivity as measured at the second cell shall be proportional to the mineral carry-over content of the steam independent of; carbon dioxide, hydroxides, carbonate, ammonia, or amine concentrations. Conductivity cells used shall cover the range 0-1 to 0-20 mho/cm according to specific application.

20.2.5 The electrode cell conductivity system shall measure the resistance of a closed loop of solution by the extent to which the loop couples two transformer coils. The liquid to be measured shall be contained in a non-conductive or non conductive lined metallic piping closed loop in which the two single winding toroidal coils are mounted on the loop piping.

20.2.6 Lining of the closed loop shall be either; glass, polyethylene, kynar or Teflon lined neoprene hose according to the specific application.

20.2.7 The toroid assembly of conductivity cell shall be hermetically sealed and each cell shall be complete with 3 meters of interconnecting cable located inside of an explosion-proof flexible conduit.

20.3 Analyzer Requirements

20.3.1 The analyzer system shall be continuous, on-line measurement instrument.

20.3.2 The electrodeless conductivity system shall be of a design to eliminate accuracy dependence upon variations in source voltage and amplifier characteristics.

20.3.3 The analyzer system shall be completely solid state type with 4-20 mA dc output signal and with local indication.

20.3.4 The analyzers receiving instrument shall be flush-mounted type to be installed on the control panel with digital bar type indicator.

20.3.5 The analyzer shall have temperature compensator circuit to correct the reading for the change of solution conductivity with temperature automatically.

20.3.6 The accuracy of the analyzer system shall be within $\pm 1\%$ of the span.

SECTION 21. TURBIDITY/SUSPENDED SOLIDS ANALYZER

21.1 Measurement System

21.1.1 Low range turbidimeter measuring principle shall be based on 90 nephelometry. The measuring system shall be equipped with bubble trap to eliminate air bubbles in the sample.

21.1.2 High range turbidimeter shall employ three geometrically positioned silicon photodiode detectors to measure 90 scattered, forward scattered and transmitted light. The ratioed signals shall be used in analyzer electronics to compensate for sample color, dust, and haze on the optical system.

21.1.3 For general applications where wide range shall be covered in presence of bubbles and larger particles, surface scatter on-line turbidimeter may be proposed. This type of measuring system shall not have any contact between the sample and optical components of the measurement system.

21.1.4 All wetted parts of measuring system shall be fabricated of corrosion resistant materials for extended life.

21.2 Analyzer Requirements

21.2.1 The turbidimeter shall be on-line, continuous measurement instrument with response time less than five minutes, totally.

21.2.2 The analyzer shall be equipped with two independent set-point alarm systems, which can be set anywhere within the overall measuring range.

21.2.3 The analyzer shall have 4-20 mA dc analog output to be connected to other devices, such as; recorders, controllers, etc., It should be equipped also with local indication.

21.2.4 The analyzer electronics shall provide selectable signal averaging time of 30, 60 or 90 seconds for "noise" minimization.

21.2.5 Key instrument functions shall be provided with self-test diagnostics. If an instrument malfunction is detected by this self-monitoring routine, an alarm signal shall be activated by the analyzer.

21.2.6 The analyzer shall have facility for allowing the instrument to be connected directly with an external computer, printer or DCS input interface, when requested in project data sheets.

21.2.7 The accuracy of the analyzer shall be within $\pm 2\%$ of full scale on the ranges below 0-30 NTU and $\pm 5\%$ on higher ranges.

21.2.8 Resolution of the analyzer readings shall be better than 0.05% of full scale.

21.2.9 Repeatability shall be better than $\pm 1\%$ of full scale.

21.2.10 Linearity shall be better than $\pm 2\%$ of full scale.

SECTION 22. RESIDUAL CHLORINE ANALYZER

22.1 Applicable Standards

ASTM D512-88	"Chlorine Ion in Water"
ASTM D1253-86	"Residual Chlorine"

22.2 Measuring System

22.2.1 The measuring system shall correlate the measurement as indicated in ASTM D512 or D1253 Standard, as may be applicable.

22.2.2 The measuring system shall have automatic color/turbidity compensation.

22.3 Analyzer Requirements

22.3.1 The analyzer shall automatically perform on-line continuous analysis for free or total chlorine at least every 2.5 minutes.

22.3.2 The analyzer shall have 4-20 mA dc output signal for external recording or control applications with local indication.

22.3.3 Dual, fully-adjustable, set-point alarms shall be incorporated in the analyzer to signal, if concentration goes outside programmed limits.

22.3.4 Range shall be within 0.5 mg/lit of free or total residual chlorine.

22.3.5 Accuracy shall be better than $\pm 5\%$ of reading.

22.3.6 Resolution shall be within 0.01 mg/lit.

22.3.7 Repeatability shall be within ± 0.05 mg/lit.

22.3.8 The analyzer shall be equipped with automatic, self-testing diagnostics to detect possible malfunctions and provide an alarm signal indicating a need for operator attention.

22.3.9 All wetted parts shall be of corrosion resistant materials.

22.3.10 Sample concentration alarms, analyzer system warning and shut-down alarms shall be each equipped with an SPDT relay with contacts rating for 5A at 230 V ac.

22.4 Sampling and Sample Conditioning System

22.4.1 Sampling system shall provide 10 psig inlet pressure of sample to the analyzer, minimally. Maximum operating pressure of the sampling and sample conditioning system shall not be considered less than 120 psig.

22.4.2 Sample flow required shall not be more than 100 mLit per minute.

22.4.3 All analyzer electronic circuits, sampling, and sample conditioning system shall be housed in an enclosure corresponding to its classified area made of epoxy coated steel plate, preferably.

SECTION 23. DISSOLVED OXYGEN ANALYZER

23.1 Applicable Standards

ASTM D888-87	"Dissolved Oxygen in Water"
ASTM D1252-88	"Chemical Oxygen Demand (COD)"
ASTM D3560-83	"Oxygen Demand"

23.2 Measuring System

23.2.1 Vendor shall propose his standard measuring system to be either; Polarographic, Galvanic, or Amperometric cell.

23.3 Analyzer Requirements

23.3.1 The analyzer shall provide; on-line, continuous measurement of dissolved oxygen.

23.3.2 Since, the solubility of oxygen in water decreases with increase in temperature and reduction in pressure; therefore, dissolved oxygen analyzer shall be temperature and pressure compensated by suitable control loops provided in the analyzer system.

23.3.3 The analyzer indicator system shall be a microprocessorbased device suitable for measurement of dissolved O₂ in fresh or saline waters, and dissolved O₂ fugacities in aqueous or non-aqueous liquids.

23.3.4 The analyzer shall have 4-20 mA dc output signal for remote recording or indication. The analyzer shall have local indication.

SECTION 24. TOTAL CARBON/ORGANIC CARBON ANALYZERS

24.1 Applicable Standards

ASTM D2579-85 "Total Carbon (TC) and Organic Carbon (TOC)"

24.2 Measuring System

24.2.1 Measuring system shall be based on chemical oxidation/IR detection technique.

24.2.2 The IR detector employed shall be designed to provide reliable operation in corrosive and dirty services.

24.2.3 All inorganic carbon in the sample shall be converted to CO₂ to be scrubbed out of the reaction solution by a nitrogen purging for TOC measurement.

24.2.4 Scrubber gas shall enter the scrubber under flow control.

24.3 Analyzer Requirements

24.3.1 The analyzer shall be on-line instrument suitable for continuous measurement of TC/TOC and shall be of microprocessor based type.

24.3.2 The instrument shall consist of two modules in separate enclosures; control module and analysis module (reaction and reagent storage) mounted on a free standing framework. The enclosures shall be splash-proof with front access.

24.3.3 The analyzer system shall provide a 4-20 mA dc signal for remote indication or recording with local indication. The analyzer shall also have facility for connection to DCS or plant computer system, where specified in the project data sheets.

24.3.4 The analyzer shall have alarm module to provide at least two alarm signals, programmable through the microprocessor system.

24.4 Sampling and Sample Conditioning System

24.4.1 Sampling system shall continuously pump the sample into the instrument.

24.4.2 For high-salt applications, hydrazine sulfate shall be injected into the sample to protect the IR detector from corrosion.

24.4.3 Sample conditioning system shall provide capability of handling suspended solids up to 2.5 mm in diameter.

24.4.4 For TOC operation, the sample conditioning system shall strip the inorganic carbon from the sample by suitable purging system and then convert it to CO₂ by oxidation reaction. The sample shall be then transferred to an automatic sampling valve which shall inject a precise amount of sample into the analyzer reactor.

24.4.5 All connections to and from the sample conditioning system shall be made by means of ¼" bulkhead union fittings.

24.4.6 Vendor shall provide the sampling and sample conditioning system with the analyzer, considering the requirements of Part 3, Article 3.2.5

SECTION 25. OIL-IN-WATER ANALYZER

25.1 Applicable Standards

ASTM D3921-85	"Oil, Grease and Hydrocarbons in Water"
ASTM D3973-85	"Low Molecular Weight Halogenated Hydrocarbons"

25.2 Measuring System

25.2.1 Vendor shall propose his standard measuring system among one of the following techniques:

- Molecular fluorescence technique,
- forward light scattering and transmittance,
- UV and visible light transmission through the sample using a dual channel photometric principle,
- solvent extraction and IR detection.

25.2.2 The measuring system shall correlate the results according to ASTM D3921 and D3973.

25.3 Analyzer Requirements

25.3.1 Oil-In-Water analyzer system shall have a completely automatic zeroing feature, permitting a continuous analysis, specific for oil, without any interference.

25.3.2 Analytical accuracy of Oil-In-Water analysis system shall be better than $\pm 2\%$.

25.3.3 Reproducibility of analysis system shall be better than $\pm 1\%$.

25.3.4 Linearity of the system shall be better than $\pm 1\%$.

25.3.5 Alarms shall be made available in the analyzer system with relay contact outputs.

25.3.6 The analyzer system shall have an output signal of 4-20 mA dc with local indication.

25.3.7 The analyzer shall have electronic automatic zeroing feature in addition to automatic turbidity compensation.

SECTION 26. HEATING VALUE (COLORIFIC VALUE) ANALYZER

26.1 Measurement System

26.1.1 Measuring system shall be of microprocessor-based Gas Chromatography system for gas custody transfer applications. The measuring technique shall involve separation and measurement of the concentration of all components present in the sample, normalization, and computation of the average heating value from the pure component's mole fractions and respective heating values.

26.1.2 The Chromatograph shall use micro-pack columns with high resolution, "backflush-to-measure" technique, and a data normalization procedure. The oven shall operate on the "heat sink" principle.

26.1.3 The Thermal Conductivity Detector employed in Chromatograph shall use two measurement and two reference thermistors in a four-element, modified whetstone bridge configuration.

26.1.4 High-Speed Open-Flame-Type measuring system shall be employed for refinery fuel gas calorimeter, to measure the heating value of gaseous fuels either as calorific value at standard conditions or as Wobbe index.

26.1.5 The Open-Flame-Type analyzer measuring principle shall be based on measuring the change in heat released by continuously burning the sample fuel and varying the flow of air to control the temperature of the mixture of air and combustion products to a specified point of equilibrium.

26.2 Analyzer Requirements

26.2.1 Gas chromatograph

26.2.1.1 The heating value Chromatograph shall be microprocessor based type. The microprocessor function shall include accurate timing of Chromatograph operations, automatic programmed calibration, precision calculations, self diagnostics, report generation, and interfacing to other devices via analog 4-20 mA dc output or by direct digital link to printer and/or host computer. The analyzer shall have local indication.

26.2.1.2 The analyzer shall have the following inputs:

- at least four sample stream inputs with automatic calibration,
- two 4-20 mA input signal from other continuous analyzer, such as; moisture or hydrogen sulfide analyzer.

26.2.1.3 The analyzer shall provide the following outputs:

- 4-20 mA output signal with local indication, assignable to any of the heating value and/or other measured quantities as required through project,
- at least 10 programmable HI/LO alarm contact outputs (30 Vdc or ac, 10 VA resistive),
- output facility for connection to printer, computer or DCS as requested through the project data sheet.

26.2.1.4 Reproducibility of the analyzer shall be $\pm \frac{1}{2}$ BTU in 1000 over the full ambient operating temperature range of 0-55°C.

26.2.1.5 Analyzer shall be provided with independent temperature controller for oven and thermal conductivity detector to conserve stability over a wide temperature fluctuations.

26.2.2 Open-flame-type analyzer

26.2.2.1 The calorimeter shall be of high speed type and shall be microprocessor-based instrument.

26.2.2.2 The microprocessor shall measure the incoming air temperature and the heated air temperature to be used for calculation and control of the measuring process. In addition, the microprocessor shall measure ambient air temperature, inlet gas temperature and flow rate of the gas inlet, to be used for calculating the heating value of the sample fuel and providing a 4-20 mA dc output signal proportional to the calculated heating value measurement.

26.2.2.3 The operator interface shall be via a keyboard, through which changes to settings are made and calibration data is entered.

26.2.2.4 Alarm facilities and auto-calibration system shall be provided for the analyzer system. Measured variables shall be stored in non-volatile memory.

26.2.2.5 Repeatability shall be $\pm 0.2\%$ of upper range value.

26.3 Sampling and Sample Conditioning System

26.3.1 Gas chromatograph

26.3.1.1 The sample handling system shall be provided by the analyzer vendor and shall typically be the same as drawings attached in section 1.0.

26.3.1.2 The sample conditioning system shall be provided with sample flow meter and needle valve to control the flow.

26.3.2 Open-flame-type

26.3.2.1 Sample conditioning system shall be provided by the vendor with all components necessary for refinery sample fuel gas conditioning.

26.3.2.2 The sample gas shall enter the instrument through a precision gas regulator, which maintains the gas pressure constant as it flows to the calibrated orifice in the burner unit.

26.3.2.3 Air shall be delivered to the instrument through a control valve and air orifice to the burner assembly.

SECTION 27. OCTANE NUMBER ANALYZER

27.1 Applicable Standards

ASTM D2699-88	"Knock Characteristics of Motor Fuels by the Research Method" #IP237-69
ASTM D2700-88	"Knock Characteristics of Motor and Aviation Fuels by the Motor Method" #IP236-69
ASTM D2885-86	"Research and Motor Method Octane Ratings Using On-line Analyzers"

27.2 Measuring System

27.2.1 ASTM-CFR engine

27.2.1.1 The ASTM-CFR engine used for measuring the octane number shall be of single cylinder heavy duty engine design with apparatus for compression ratio adjustment between 4 to 18.

27.2.2 Correlative measuring technique

27.2.2.1 The correlative measuring technique shall be based on "cool flame" Octane analyzer technology.

27.2.2.2 The measuring system shall employ a reactor tube maintained at an elevated temperature to perform partial exothermic oxidation.

27.2.3 Refractive index measurement

27.2.3.1 This type of instrument shall use differential refractometer for measurement of Octane improvement in the hydroforming process.

27.3 Analyzer Requirements

27.3.1 ASTM-CFR engine analyzer

27.3.1.1 The Octane analyzer shall be suitable for automatic on-line measurement of the octane number of in-line blended gasoline or process streams used as gasoline blend stocks.

27.3.1.2 The analyzer shall consist of an ASTM-CFR engine and the comparator unit. The Octane comparator equipment shall consist of the following five basic assemblies:

a) Analyzer console

The console shall be a pedestal-mounted enclosure complete with; display instruments housing, operational switches, controls, sequencing devices, and analog signal handling circuits. The console shall be installed on the engine skid and connected to it by electrical cables.

The Differential Octane Number (ON) value shall be displayed on an indicating meter and recorder mounted on the analyzer console.

b) Engine interconnection unit

An enclosure containing the relay chassis, control unit for automatic Compression Ratio (CR) adjustment, electrical connectors, and terminal strips.

c) Fuel panel

Panel shall be of wall mounting design type and shall contain all components required to condition and deliver prototype and sample fuels to the engine.

d) ASTM engine accessories

- 1) A converter assembly to produce electrical output proportional to Compression Ratio (CR), and a CR safety limit switch. Both devices shall be mounted on the engine cylinder and sleeve assembly.
- 2) A carburetor modification kit to achieve conversion to the "flow-through" principle that allows large volume sample fuel flow. Carburetor devices shall include a special selector valve, a fuel suction tube for removal of excess sample fuel, a sample fuel rotameter, and suitable carburetor cooling and fuel overflow safety devices.

e) Fuel cooling unit

Fuel cooling unit shall be a mechanical water chiller and circulating pump for installation behind the engine for cooling sample and prototype fuels.

27.3.1.3 Alarm contacts shall be provided for remote annunciation of engine shutdown, sample shutoff, Compression Ratio (CR) high and low limit. In addition, safety actuators shall be provided in conjunction with these alarm conditions. Power shall be removed from the analyzer console if the engine shuts down. Sample fuel shall be shut off and the operation shall be locked in proto type mode if any of several fuel conditions are detected to be abnormal.

27.3.1.4 Generally, the octane analyzer shall meet all requirements of ASTM D2885.

27.3.1.5 A computer Octane Analysis Control system shall be provided to automate in-line gasoline blending units up to three separate blenders. The engines shall be provided with suitable computer interfacing equipment, such as Knock Intensity (KI) and Compression Ratio (CR) transducers, safety alarm sensors, fuel conditioning, and cooling equipment. The computer shall automatically control the knock Intensity of each engine by CR adjustment, sequentially operate the engines on prototype and product fuels, and compute Road Octane Number from delta RON and delta MON (Motor Octane Number) input data.

27.3.1.6 A single-bay steel enclosure shall house the computer and computer interface equipment, consisting of the following:

- DEC PDP-11, VAX-4000 or equivalent computer, with programming panel and dual floppy disk storage,
- operator's panel,
- computer interface equipment, which shall include power supplies, input/output logic, analog-to-digital converters, and I/O termination facilities.

27.3.1.7 The master analysis program shall be permanently stored on floppy disk to be loaded into the computer when required. Subroutines to perform calculations, such as; Reid Vapor Pressure (RVP), Lead-in -gasoline, and Vapor to Liquid (V/L) ratio, shall be provided in the computer, working on the basis of input data from other analyzers.

27.3.1.8 The computer system shall be switched to full on-line analysis by a dedicated RUN switch. The RUN mode shall be inhibited unless the following conditions are satisfied:

- both Research Octane Number (RON) and Motor Octane Number (MON) interface units are in the Auto mode;
- the computer program is running correctly;
- the product fuel systems are operative.

If during computer run cycle, any interlock condition fails, the system shall automatically revert to standby. If any blending stream engine fail-safe devices cause an engine shutdown, the computer shall be disconnected from that engine, since that engine will revert to the manual mode.

27.3.1.9 Print-out of blend quality information shall be programmed in the computer system to occur on a predetermined time basis. Such data shall include:

- instantaneous Differential Research Octane Number (Δ RON), Differential Motor Octane Number (Δ MON), and Differential Road Octane Number;
- instantaneous RON, MON, and Road ON;
- flow weighted averages for RON, MON and Road ON.

SECTION 28. THERMAL CONDUCTIVITY (TC) ANALYZER

28.1 Measuring System

28.1.1 The measuring system shall consist of a measuring cell and a temperature-controlled oven in which the cell shall be located.

28.1.2 The oven shall be fabricated of stainless steel metal block and shall be machined to provide flow passages for the sample and the reference gas and recessed cavities for the sensing elements. The oven shall be temperature controlled in a manner to provide constant temperature across the sensing element.

28.1.3 The measuring cell shall be of 316 stainless steel with Teflon coated tungsten or platinum alloy filaments and shall consist of relatively large mass of metal to provide a stable heat sink and, at the same time, shall have a high thermal-conductivity coefficient.

28.1.4 The hot-wire filaments shall be used in two pairs minimally; a pair located in the sample stream, and the other pair in the reference gas.

28.2 Analyzer Requirements

28.2.1 The thermal conductivity analyzer shall consist of three major components; the measuring cell, a whetstone bridge circuit with regulated power supply, and a temperature-controlled oven.

28.2.2 The reference and sample filaments shall be connected to form the arms of the whetstone bridge circuit, which shall receive the power from an internal precise voltage-regulated power supply.

28.2.3 The analyzer oven shall be maintained at a constant temperature by a heater and a solid-state temperature controller.

28.2.4 The analyzer module shall contain all required solid-state circuitry to condition the bridge unbalance signal, as required, to provide a read-out on the front panel meter and 4-20 mA dc current output for remote recording or connection to DCS with local indication.

28.2.5 Accuracy and reproducibility of the analyzer shall be within $\pm 2\%$ of full scale.

SECTION 29. REFRACTIVE INDEX MEASUREMENT ANALYZER

29.1 Applicable Standards

ASTM-D1218-87	"Refractive Index and Refractive Dispersion of Hydrocarbon Liquids"
ASTM-D1747-84	"Refractive Index of Viscous Materials"

29.2 Measuring System

29.2.1 The refractive Index analyzer shall operate on the critical angle principle requiring no depth of penetration of the sample by the light beam.

29.2.2 The measuring element shall be capable to be installed either in a connecting pipeline or mounted in the wall of a process vessel by a coupling flange at pressures up to 1000 psig and temperatures up to 220°C.

29.2.3 The optical system used in the measuring system, including prisms and lenses, shall be of the best quality available.

29.2.4 A silicon-junction temperature sensing probe shall be mounted in the sensing head adjacent to the prism connected to the electronic circuitry to provide automatic temperature compensation.

29.2.5 Sensing heads shall be constructed in stainless steel in general applications, other corrosion resistant materials shall be proposed in specific corrosive applications.

29.2.6 In specific applications, valve type bodies' sensing element may be proposed with suitable linings to suit the application.

29.2.7 Refractometer system shall use a two-pass, four refracting surface cell to amplify the differences in refractive index between the flowing sample and a reference liquid sealed in the prism shaped cell. This light beam position shall be detected by a null balance system. As the moisture content of the sample stream changes, the light beam is refracted more or less, changing the relative amounts of light reaching the two photocells. A whetstone bridge measuring circuit shall be provided to become unbalanced and the signal shall be feedback to the servo-motor. The servo-motor shall drive the beam deflector plate in a direction to equalize the light reaching the two photo cells. The position of the deflector plate should be a measure of the refractive index and water concentration of the sample.

29.3 Analyzer Requirements

29.3.1 The analyzer shall be on-line, continuous instrument.

29.3.2 The analyzer repeatability shall be within 0.5% of full scale with continuous on-line measurement of the process fluid encountered.

29.3.3 The instrument shall consist of a sensing unit and the control unit.

29.3.4 An automatic gain control circuit shall be provided in the control unit to maintain the light source at the degree of illumination irrespective of the power supply variations, component aging, and so on.

29.3.5 Automatic temperature compensation control circuit shall be provided, using the thermistor probe mounted adjacent to the measuring prism.

29.3.6 Manual ultrasonic cleaning shall be provided for cleaning the sensing unit.

29.3.7 The control unit shall have span, zero, and temperature compensation adjustments, a liquid crystal display of the measured variable, a process temperature indicator, and a prism wash push button.

29.3.8 The analyzer shall have 4-20 mA dc signal output for remote recording or connection to DCS or plant computer, with local indication.

SECTION 30. FLUE GAS ANALYZER (COMBUSTION EFFICIENCY MONITORING AND CONTROL)

30.1 Measuring System

30.1.1 The measuring system shall include analyzers for O₂, CO CO₂, opacity, and hydrocarbons measurement in the stack flue gas.

30.1.2 The Oxygen analyzer shall be of Zirconia type with 0-25% O₂ range.

30.1.3 CO and CO₂ measuring system shall use a narrow-band non-dispersive IR absorption technique within the ranges 0-5000 vol ppm of CO and 0-20% volume/volume, wet basis CO₂.

30.1.4 The combustible sensors shall consist of two sensing elements, a catalytically active element and a reference element which shall be maintained at a constant temperature. The current decrease that occurs when combustible gases burn on the catalytic element shall provide the output signal to the analyzer control unit. The range shall be within 0-5% methane (CH₄) equivalent.

30.2 Analyzer Requirements

30.2.1 The analyzer shall be On-line type suitable for continuous measurement of the stack flue gas.

30.2.2 The analyzer control unit shall be microprocessor based and shall perform all supervisory and monitoring functions for the system, including self-diagnostic routines and CO analyzer calibration.

30.2.3 The analyzer system shall be suitable to interface with plant instrumentation and shall have 4 to 20 mA. dc output with local indication.

30.2.4 Instrument response time shall be within 1 sec.

30.2.5 The analyzer system shall employ solid state modular electronic circuits mounted on plug-in boards for easy maintenance and trouble-shooting.

30.2.6 The measuring system shall be housed in weather-resistant explosion-proof enclosure and shall be suitable for "bulk-head union" type installation.

30.2.7 The operating temperature range shall meet the requirement in accordance to the site ambient temperature.

30.3 Sampling and Sample Conditioning

30.3.1 Vendor shall provide complete sampling and sample conditioning system considering the following criteria:

- For clean natural gas burning installations, suction facility by air ejector should be used.
- For dirtier flue gas applications (such as heavy oil fired furnaces) a pump, along with a water spray on the probe, a water wash line, and a water wash in the analysis system shall be provided.

30.3.2 The sample conditioning system shall precondition the sample stream to cool the gases, and remove particulates and contaminants to assure a clean and continuous sample flow for analysis.

30.3.3 Requirements set-forth in Part 3, Article 3.2.5 shall also be considered herein.

SECTION 31. SALT-IN-CRUDE MONITOR ANALYZER

31.1 Applicable Standards

ASTM-D3230-83 "Test Method for Salt-In-Crude Oil (Electrometric Method)"

31.2 Measuring System

31.2.1 The measuring system shall consist of a test cell and an electrical conductivity measurement system.

31.2.2 The test cell shall be equipped with heater and stirring devices to break down any crude molecules which might have trapped chlorides or other suspended solid matters.

31.2.3 Reagents (i.e., Alcohol and Xylene) shall be collected of predetermined volume with a precise volume of crude sample into the test cell.

31.2.4 The collected sample introduced into the test cell, shall be heated and mixed for a predetermined interval.

31.2.5 A microprocessor shall be provided to sequence the set of solenoid valves to assure proper blending and sample conditioning, prior to measurement.

31.3 Analyzer Requirements

31.3.1 The instrument shall consist of a field-mounted measurement unit and a remote display/controller. Operation shall be possible from either the measurement unit or the remote display/controller with the exception of Calibration and Manual-Zeroing.

31.3.2 The instrument shall be microprocessor based to control all sampling and measurement functions and shall provide; remote operation, single and repetitive analysis, menu driven calibration, and autozero. The microprocessor shall also provide any user programmed or automatic functions in addition to a built-in diagnostics.

31.3.3 The Salt-In-Crude analyzer shall be an on-stream process analyzer to measure the salt concentration of the crude oil with range of 0 to 100 Pounds per Thousands Barrels (PTB) or 0 to 285 mg/Lit. Measurement shall correlate the results in accordance with ASTM D3230 Standard.

31.3.4 Accuracy shall be within $\pm 5\%$ of indicated salt content with average repeatability of $\pm 1.5\%$.

31.3.5 In addition to concentration reading on alpha/numeric display, the instrument shall provide user scalable 4-20 mA dc isolated output signal.