Specification for Oil and Gas Separators

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a. This specification is under the jurisdiction of the API Committee on Standardization of Production Equipment.

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NOTE: This edition supersedes the sixth edition, and includes revisions approved at the 1988 Standardization Conference as reported in Circ PS-1858 and subsequently approved by letter ballot.

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SECTION 1
SCOPE

1.1 Coverage. This specification covers minimum requirements for the design, fabrication, and shop testing of oilfield type oil and gas separators and/or oil-gas-water separators used in the production of oil and/or gas, and usually located but not limited to some point on the producing flowline between the wellhead and pipeline. Separators covered by this specification may be vertical, spherical, or single or double barrel horizontal. Unless otherwise agreed upon between the purchaser and the manufacturer, the jurisdiction of this specification terminates with the pressure vessel as defined in the Scope of Section VIII, Division 1 of the *ASME Boiler and Pressure Vessel Code*[1], hereinafter referred to as the ASME Code. Pressure vessels covered by this specification are normally classified as natural resource vessels by API 510 *Pressure Vessel Inspection Code*[2]. Separators outside the scope of this specification include centrifugal separators, filter separators, and desanding separators.

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[1]Available from the American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

[2]Available from American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

SECTION 2
DEFINITIONS

2.1 Introduction. The separation of gas and liquids primarily relies on physical differences in the phases. This section covers mechanical separation of liquids and gases.

2.2 Terminology. A separator vessel may be referred to as a knockout, trap, scrubber, flash chamber, or expansion vessel as well as the original term. This terminology is applied regardless of shape. Generally, the following definitions are regarded as basic:

2.2.1 Separator — A separator is a vessel used in the field to remove wellstream liquid(s) from gas components. The separator may be either two-phase or three-phase. Two-phase separators remove the total liquid from the gas, while three-phase separators also remove free water from the hydrocarbon liquid.

2.2.2 Scrubber — A scrubber is a type of separator which has been designed to handle flow streams with unusually high gas-to-liquid ratios. These are commonly used in conjunction with dehydrators, extraction plants, instruments, or compressors for protection from entrained liquids.

2.2.3 Knockout — A knockout is a type of separator which falls into one of two categories: free water and total liquid knockouts.

a. The free water knockout is a vessel used to separate free water from a flow stream of gas, oil, and water. The gas and oil usually leave the vessel through the same outlet to be processed by other equipment. The water is removed for disposal.

b. The total liquid knockout is normally used to remove the combined liquids from a gas stream.

2.3 Maximum Allowable Working Pressure — The maximum allowable working pressure (MAWP) is the maximum pressure, permissible by the ASME Code, at the top of the separator in its normal operating position for a designated temperature.

2.4 Operating Pressure — The operating pressure is the pressure in the vessel during normal operation. The operating pressure shall not exceed the MAWP, and is usually kept at a suitable level below the setting of the pressure relieving devices to prevent their frequent opening. (See Appendix A.)

2.5 Corrosion. Corrosion is defined as the destruction of a metal by chemical or electrochemical reaction with its environment. (See Appendix B.)

SECTION 3
MATERIAL

3.1 ASME Code. Separators furnished to this specification shall conform to the material requirements stipulated in the latest edition of the ASME Code.

3.2 Material selection for corrosive fluids should be selected based on a review of related API or NACE publications for materials that conform to Paragraph 3.1. Consideration should be given to material selection as it relates to weight loss, sulphide stress cracking, chloride stress cracking, or *other forms* of corrosion. It is the responsibility of the user to determine what consideration for corrosion should be made to the vessel during its intended life. (Reference ASME Code, as applicable to corrosion.) Corrosion guidelines are given in Appendix B.

3.3 Corrosion consideration for separators furnished to this specification shall be for the pressure containing parts of the *vessel only*, and as can be identified as falling within the requirements of the applicable sections of the ASME Code. Corrosion considerations for vessel internals (non-pressure parts) is by mutual agreement between the purchaser and the manufacturer and not a part of this specification.

SECTION 4
DESIGN

4.1 Type, Size, Pressure and Temperature Ratings — Separators furnished to this specification may be vertical, horizontal, or spherical, and are available in sizes and maximum allowable working pressure ratings shown in Tables 4.1, 4.2, and 4.3. The following tables are for nominal industry standards. Available sizes and working pressures may vary from the stated ratings. Other sizes, pressure, and temperature ratings may be furnished by agreement between purchaser and manufacturer.

4.2 Typical Process Design and Sizing Calculations are given in Appendix C.

4.3 A suggested checklist of separator design information is included in Appendix E.

4.4 Appendix D gives an example calculation for separator sizing.

TABLE 4.1
HORIZONTAL SEPARATORS
SIZE AND WORKING PRESSURE RATINGS

Nominal Diameter, Inches	Maximum Allowable Working Pressure, PSIG @ 130°F.						
12¾	...	230	600	1000	1200	1440	2000
16	...	230	600	1000	1200	1440	2000
20	125	230	600	1000	1200	1440	2000
24	125	230	600	1000	1200	1440	2000
30	125	230	600	1000	1200	1440	2000
36	125	230	600	1000	1200	1440	2000
42	125	230	600	1000	1200	1440	2000
48	125	230	600	1000	1200	1440	2000
54	125	230	600	1000	1200	1440	2000
60	125	230	600	1000	1200	1440	2000

Notes: a. Shell length is generally expanded in 2½ foot increments measured from head seam to head seam and is typically 5 feet, 7½ feet, or 10 feet. A minimum length-to-diameter ratio of 2.0 is normally used.
b. Vessel diameter is generally expanded in 6 inch increments, measured either as outside diameter (OD) or inside diameter (ID). OD separators are normally furnished up to 24 inch diameter. Separators above this size may be either OD or ID vessels.

TABLE 4.2
VERTICAL SEPARATORS
SIZE AND WORKING PRESSURE RATINGS

Nominal Diameter, Inches	Maximum Allowable Working Pressure, PSIG @ 130°F.						
16	...	230	600	1000	1200	1440	2000
20	125	230	600	1000	1200	1440	2000
24	125	230	600	1000	1200	1440	2000
30	125	230	600	1000	1200	1440	2000
36	125	230	600	1000	1200	1440	2000
42	125	230	600	1000	1200	1440	2000
48	125	230	600	1000	1200	1440	2000
54	125	230	600	1000	1200	1440	2000
60	125	230	600	1000	1200	1440	2000

Notes: a. Shell length is generally expanded in 2½ foot increments measured from head seam to head seam and is typically 5 feet, 7½ feet, or 10 feet. A minimum length-to-diameter ratio of 2.0 is normally used.

b. Vessel diameter is generally expanded in 6 inch increments, measured either as outside diameter (OD) or inside diameter (ID). OD separators are normally furnished up to 24 inch diameter. Separators above this size may be either OD or ID vessels.

TABLE 4.3
SPHERICAL SEPARATORS
SIZE AND WORKING PRESSURE RATINGS

Nominal Outside Diameter, Inches	Maximum Allowable Working Pressure, PSIG @ 130°F.						
24	...	230	600	1000	1200	1440	2000
30	...	230	600	1000	1200	1440	2000
36	...	230	600	1000	1200	1440	2000
41	125	230	600	1000	1200	1440	2000
42	125	230	600	1000	1200	1440	2000
48	125	230	600	1000	1200	1440	2000
54	125	230	600	1000	1200	1440	2000
60	125	230	600	1000	1200	1440	2000

SECTION 5
FABRICATION, TESTING, AND PAINTING

5.1 Separators shall be shop constructed, tested, and stamped in accordance with the latest edition of ASME Code. Additional testing for internal or external leaks may be required by agreement between the purchaser and manufacturer.

5.2 Painting. Before shipment, separators shall be cleaned of rust, grease, scale, and weld spatter, and externally coated with one application of a good grade of commercial metal primer. Internal coating and finish coating shall be applied if so agreed upon between the purchaser and manufacturer. Special access may be required to adequately apply internal coatings to smaller diameter vessels.

5.3 Internal Coating. Where internal coating is specified by the purchaser, all non-removable internal attachments shall be seal welded and prepared for coating in accordance with the purchaser's specifications. In the absence of purchaser's specifications, some acceptable practices are listed in Appendix B. After coating, the vessel shall be stenciled in a conspicuous location "INTERNAL COATING — DO NOT WELD."

5.4 Preparation for Shipment. Prior to shipment all foreign matter (including hydro-test water) shall be removed from the vessel, both internally and externally. All openings shall be protected with shipping covers or plugs.

SECTION 6
MARKING

6.1 API Nameplate. Separators furnished to this specification shall be identified by a nameplate of corrosion resistant material securely attached to a suitable bracket welded to the shell, or stamped on a steel nameplate seal welded to the shell. The nameplate shall bear the information in items 1 through 9 below, as shown in Figure 6.1.

1. Spec 12J
2. Manufacturer's name
3. Manufacturer's serial number
4. Year built
5. Weight empty, pounds
6. Shell size, OD × length
7. Maximum allowable working pressure, psi at maximum design temperature, degrees Fahrenheit. Also, minimum temperature if required by the ASME Code or specified by the purchaser.
8. Additional information required by state or other political subdivision regulations.
9. Additional markings desired by the manufacturer or requested by the purchaser are not prohibited.

6.2 ASME Code Nameplate. Separators furnished to this specification shall have a nameplate affixed to the vessel as required by the latest edition of the ASME Code. In lieu of a separate API nameplate and at the discretion of the manufacturer, the information required by Paragraph 6.1 may be included below the ASME Code required marking on the ASME Code nameplate.

6.3 Stamping. Stamping directly on the separator shell may be injurious and should be avoided. See ASME Code for allowable stamping.

*Users of this specification should note that there is no longer a requirement for marking a product with the API monogram. The American Petroleum Institute continues to license use of the monogram on products covered by this specification but it is administered by the staff of the Institute separately from the specification. The policy describing licensing and use of the monogram is contained in Appendix F, herein. No other use of the monogram is permitted.

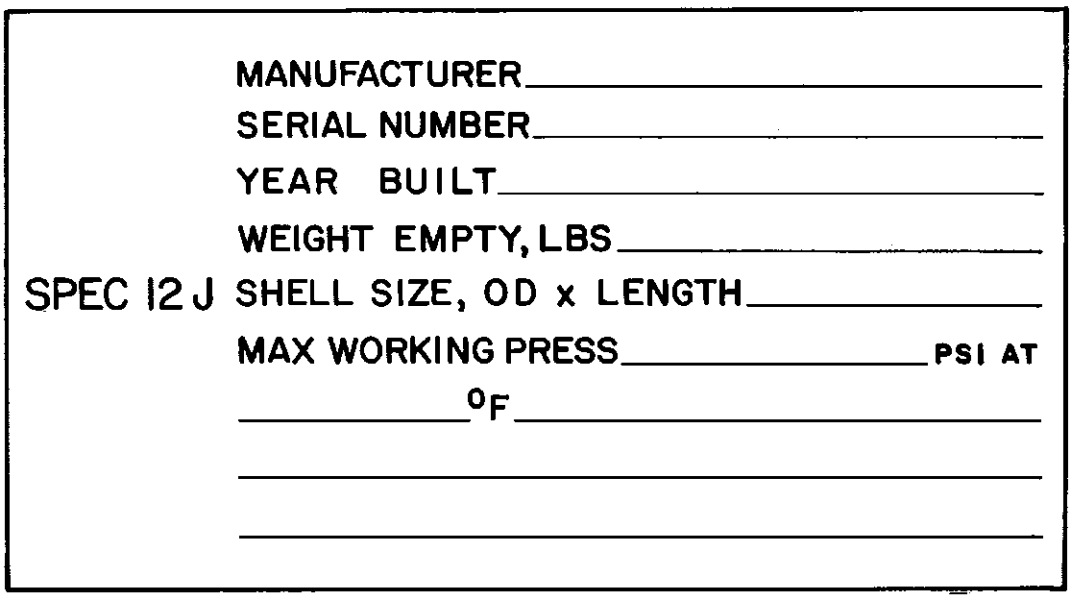


FIGURE 6.1
SEPARATOR NAMEPLATE FORMAT
(See Paragraph 6.1)

SECTION 7
INSPECTION AND REJECTION

7.1 ASME Code Inspection. The Authorized Inspector required by the ASME Code shall make all inspections specifically required by the Code plus such other inspections believed necessary to certify that all vessels authorized to be stamped with the Code symbol meet all of the applicable requirements of the Code. The Authorized Inspector shall sign the Certificate of Inspection on the Manufacturers Data Report when the vessel, to the best of the inspector's knowledge and belief, is complete and is in compliance with all the provisions of the Code.

7.2 Inspection by the Purchaser. Where additional inspection is required by the purchaser, the extent of such inspection should be stated on the purchase order. Where the inspector representing the purchaser desires to inspect separators purchased or witness any specification tests or evaluate the results of any nondestructive examinations, the manufacturer shall give reasonable notice of the time at which such inspections should be made.

7.3 Inspection. While work on the contract of the purchaser is being performed, the inspector representing the purchaser shall have free entry at all times to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford, without charge, all reasonable facilities to satisfy the inspector that the material is being manufactured in accordance with this specification. All inspections shall be made at the place of manufacture prior to shipment unless otherwise specified on the purchase order, and shall be so conducted as not to interfere unnecessarily with the manufacturer's operations.

7.4 Rejection. Material which shows injurious defects on initial inspection or subsequent to acceptance at manufacturer's works, or which proves defective when properly applied in service, may be rejected, and the manufacturer so notified. If tests that require the destruction of material are made at other than the place of manufacture, the purchaser shall pay for material complying with all of the provisions of this specification, but shall not pay for any material which fails to meet the specifications.

7.5 Compliance. The manufacturer is responsible for complying with all of the provisions of this specification. The purchaser may make any investigation necessary to be assured of compliance by the manufacturer and may reject any material that does not comply with this specification.

APPENDIX A
PROCESS CONSIDERATIONS

A.1 This Appendix provides a general discussion of the functional requirements of Oil and Gas Separators and their controls as used in this specification.

A.2 Separator Components. The function of a separator is to provide removal of free gas from oil and/or water at a specific pressure and temperature. For efficient and stable operation over a wide range of conditions, a gas-liquid separator normally has the following features:

A.2.1 Primary Separation Section — This section is for removing the bulk of the liquid in the inlet stream. Liquid slugs and large liquid particles are removed first to minimize gas turbulence and re-entrainment of liquid particles in preparation for the second step of separation. To do this, it is usually necessary to absorb the momentum and change the direction of flow by some form of inlet baffling.

A.2.2 Secondary Separation Section — The major separation principle in this section is gravity settling of liquid from the gas stream after its velocity has been reduced. The efficiency of this section depends on the gas and liquid properties, particle size and degree of gas turbulence. Some designs use internal baffling to reduce turbulence and to dissipate foam. The baffles may also act as droplet collectors.

A.2.3 Liquid Accumulator Section — The liquid(s) is (are) collected in this section. The liquid should have a minimum of disturbance from the flowing gas stream. Sufficient capacity is necessary to allow for surges and to provide the retention time necessary for efficient separation of gas breaking out of solution and separation of free water from oil in three-phase separators. A vortex breaker may be located over the liquid outlet nozzle(s) to prevent gas or oil entrainment with the bottom liquid.

A.2.4 Mist Extraction Section — The mist extractor of the coalescing section can be one

of several designs (a series of vanes, woven wire mesh pad or a centrifugal device). The mist extractor removes from the gas stream the small droplets (normally down to 10 micron diameter) of liquid before the gas leaves the vessel. Liquid carryover is normally less than 0.1 gallon per MMSCF.

A.2.5 Process Controls — The operating pressure may be controlled by a weight loaded, spring loaded, or pilot operated gas back pressure valve. Where the gas is being delivered to a pipeline, the minimum separator pressure is usually set by the transmission or gathering system pressure. Separators should be equipped with one or more liquid level controls. Usually a liquid level control for the liquid accumulation section of two-phase separators activates a liquid dump valve to maintain the required liquid level. Two liquid level control systems are normally used for three-phase separators. Internal weirs and baffles are used in conjunction with these liquid level controls. Separators are equipped with gauge glasses or sight glasses to indicate one or two levels. A pressure gauge and thermometer well are usually installed on separators.

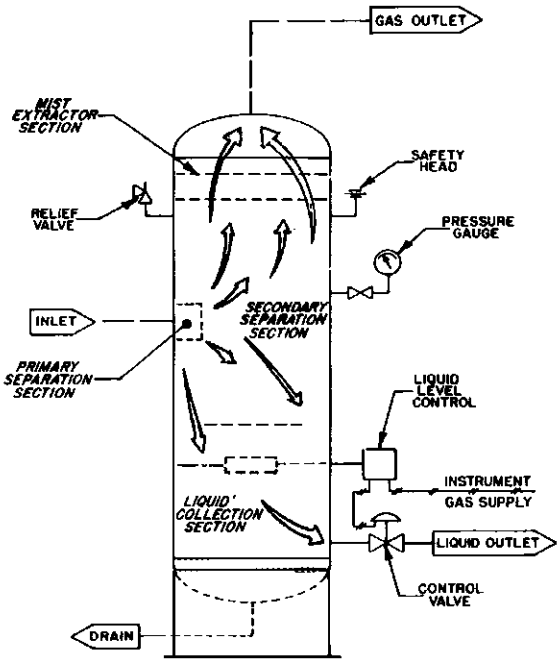
A.2.6 Relief Devices — All separators, regardless of size or pressure, shall be provided with pressure protective devices and set in accordance with ASME Code requirements. Multiple pressure relieving devices such as a pressure relief valve in conjunction with a rupture disk may be used to provide the necessary relieving capacity. The relief valve is normally set at the maximum allowable working pressure (MAWP). The rupture disk is normally selected to relieve above the set pressure of the relief valve. The pressure relief devices need not be provided by the separator manufacturer, but over-pressure protection shall be provided prior to placing the separator in service. The purchaser should determine who has the responsibility to furnish relief devices.

A.2.7 Discharge Lines — Discharge lines from pressure relief devices should receive consideration on an individual basis. A detailed discussion is beyond the scope of this standard. Recommendations for discharge line consideration may be obtained from Appendix M, Installation and Operation, of the ASME Code as well as API RP 520, "Design and Installation of Pressure Relieving Systems in Refineries" and API RP 521, "Guide for Pressure Relief Systems and Depressuring Systems."

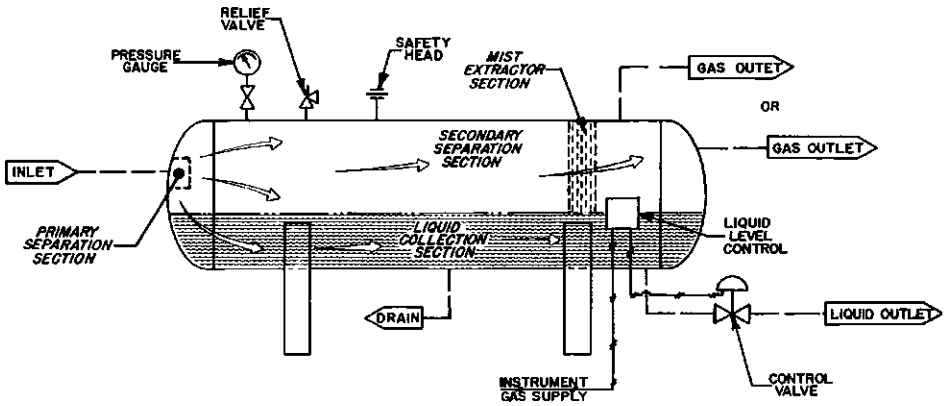
A.2.8 When specified by the purchaser, separators may be equipped with other controls and accessories such as the following:

a. Inlet shut-in valve
b. Pressure sensor or conrol
c. Level sensor or control
d. Temperature sensor or control

A.3 Separator Shapes — There are three different shapes of separators: vertical, horizontal, and spherical. The four main components are located differently in the various vessels. In Figure A-1 are given typical two-phase separator configurations for vertical, horizontal, and spherical separators.

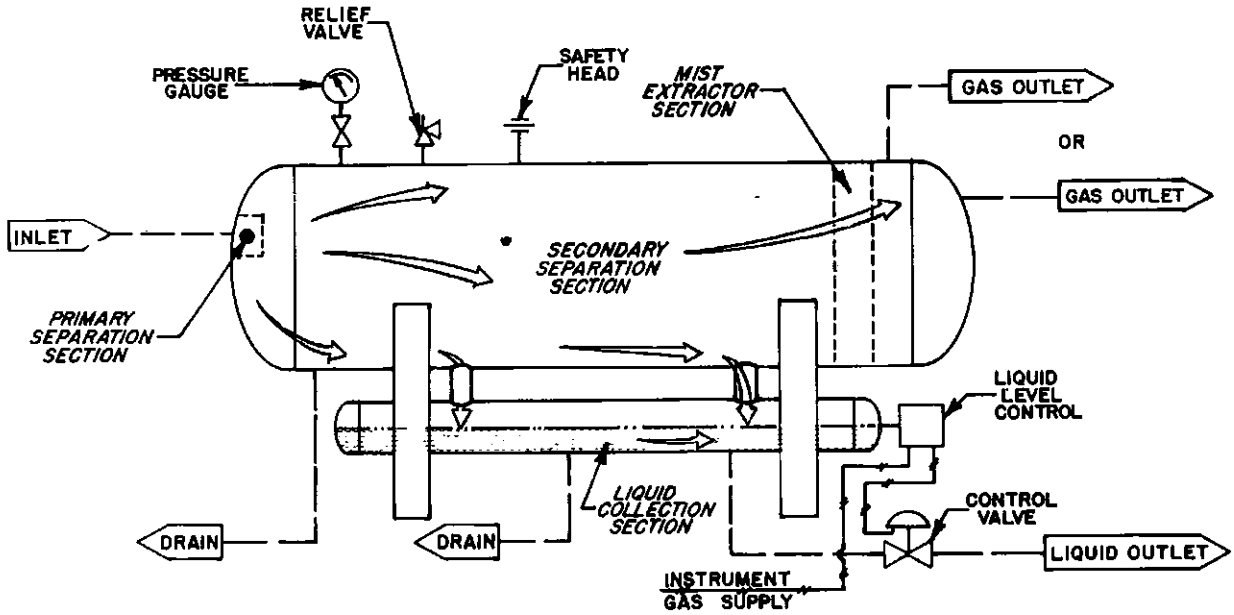


VERTICAL 2 PHASE SEPARATOR

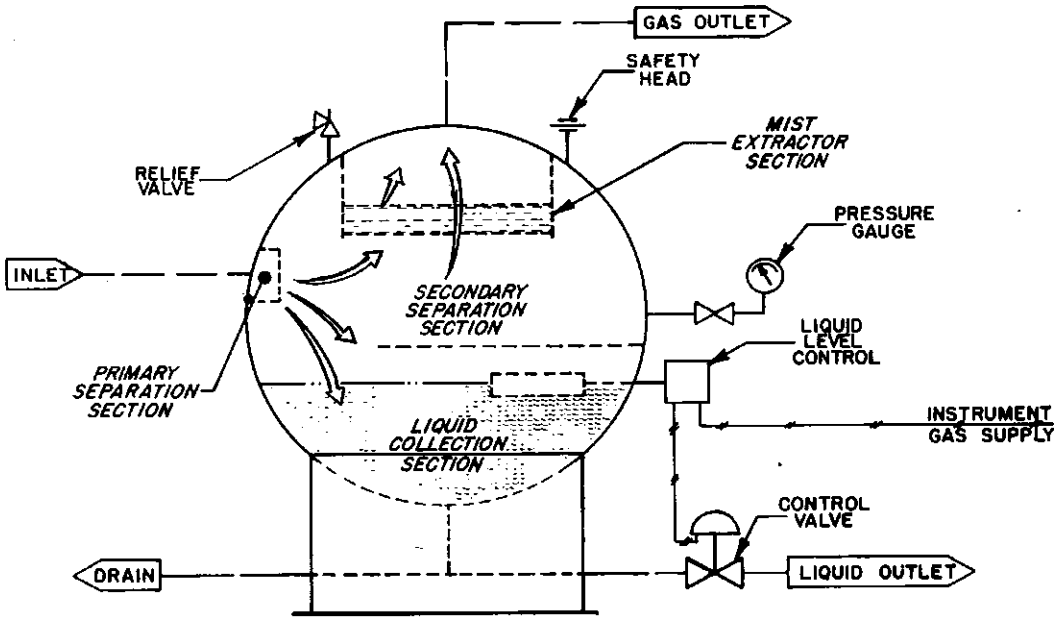


HORIZONTAL 2 PHASE SEPARATOR

FIGURE A-1
TWO-PHASE SEPARATOR CONFIGURATIONS



HORIZONTAL 2 PHASE DOUBLE BARREL SEPARATOR



SPHERICAL 2 PHASE SEPARATOR

FIGURE A-1 CONTINUED
TWO-PHASE SEPARATOR CONFIGURATIONS

APPENDIX B
CORROSION GUIDELINES

B.1 Considerations. The following *guidelines* are recommended for determining corrosion considerations for an applicable vessel:

B.1.1 Well streams that contain water as a liquid and any or all of the following gases are considered to be corrosive and are due consideration under these specifications (reference API RP 14E, ASME Code, NACE MR-01-75 and MR-05-75):

a. Oxygen — 0_2

b. Carbon Dioxide — CO_2

c. Hydrogen Sulfide — H_2S

B.1.2 The following guidelines are not mandatory but may be used to judge the extent of the corrosive environment, with respect to carbon steels:

a. Oxygen

(1) Less than 0.005 ppm in natural brine — non-corrosive

(2) From 0.005 ppm to 0.025 ppm requires consideration

(3) Greater than 0.025 ppm in natural brine — corrosive

b. Carbon Dioxide

(1) Less than 600 ppm in natural brine — non-corrosive

(2) From 600 ppm to 1200 ppm requires consideration

(3) Greater than 1200 ppm in natural brine — corrosive

c. Hydrogen Sulfide

(1) No lower limit of hydrogen sulfide has been identified as being non-corrosive. With hydrogen sulfide presence, the environment should be considered corrosive.

(2) NACE Standard MR-01-75 (latest edition) should be used for all cases of hydrogen sulfide content for judgment of the possibility of Sulfide Stress Cracking (SSC) and is extracted as follows: "Systems operating below 65 psia total pressure or below 0.05 psi H_2S partial pressure are outside the scope of this standard."

B.1.3 Should alloy steel or stainless steel be used, other forms of corrosion should be considered such as, but not limited to, chloride stress cracking.

B.1.4 Some of the other factors that influence corrosion in a given vessel include: temperature, pressure, fluid velocities, metal stress and heat treatment, vessel surface condition, and time.

B.2 Corrosive Environment Practices.

B.2.1 If the environment is judged as being subject to SSC from the criteria of NACE MR-01-75 as stated in B.1.2 above, then all provisions of this NACE Standard as apply to the vessel materials and construction shall be followed.

B.2.2 If the environment is judged as corrosive from any of the other criteria stated in B.1.2 above, the intent of this specification will be met provided any one or combination of the following practices are used:

a. An allowance for corrosion to the vessel parts may be made according to the ASME Code, Appendix E, *Suggested Good Practices Regarding Corrosion Allowance.*

b. Either sacrificial or impressed current anodes may be used, providing that the area of the corrosion attack *can physically be* protected by use of these anodes (NACE Ref. RP-05-75).

c. Corrosion effects may be controlled with holiday-free internal coatings on all exposed metal surfaces. NACE Standards RP-01-81 *(Recommended Practice: Liquid Applied Internal Protective Linings and Coatings for Oil Field Production Equipment)* and RP-01-78 *(Design, Fabrication, and Surface Finish of Metal Tanks and Vessels to be lined for Chemical Immersion Service)* present guidelines and procedures for coating vessels such as oil and gas separators.

d. Corrosion effects may be disregarded provided they can be shown to be negligible or entirely absent on a historical basis. However, the system should be monitored periodically for possible new corrosion (Reference API 510).

e. Corrosion effects may be reasonably controlled with chemical inhibitor treatments.

B.2.3 Post weld heat treatment is recommended for carbon steel vessels for use in acid gas (containing hydrogen sulfide and/or carbon dioxide) service. Post weld heat treatment may be required by ASME Code regardless of corrosion considerations.

APPENDIX C
DESIGN AND SIZING CALCULATIONS

C.1 Sizing of Two-Phase Oil-Gas Separators. The following calculations are presented as a guide to the design and sizing of two-phase and three-phase separators. Sizing should be based on the maximum expected instantaneous rate.

C.1.1 Theory and Equations — Gas capacities of separators may be determined by a modification of Stokes' Law. When using Stokes' Law, the capacity is based on the principle of the minimum droplet size that will settle out of a moving gas stream at a given velocity. The maximum allowable superficial velocity of the gas at operating conditions is calculated by the following formula: (See Appendix D for separator sizing example calculation.)

$$V_a = K\sqrt{\frac{d_L - d_G}{d_G}} \qquad \text{Equation C.1.1}$$

Where: V_a = Maximum allowable superficial velocity in feet per second through the secondary separation section

d_L = Density of the liquid in pounds per cubic foot at operating conditions

d_G = Density of the gas in pounds per cubic foot at operating conditions

K = A constant depending upon design and operating conditions

TABLE C.1
K FACTORS FOR DETERMINING MAXIMUM ALLOWABLE SUPERFICIAL VELOCITY

Type Separator	Height or Length L (Feet)	Typical K Factor Range
Vertical	5	0.12 to 0.24
	10	0.18 to 0.35
Horizontal	10	0.40 to 0.50
	Other Lengths	$0.40 \text{ to } 0.50 \times (L/10)^{0.56}$
Spherical	All	0.2 to 0.35

C.1.2 The maximum allowable superficial velocity calculated from the above factors is for separators normally having a wire mesh mist extractor. This rate should allow all liquid droplets larger than 10 microns to settle out of the gas. The maximum allowable superficial velocity or other design criteria should be considered for other type mist extractors. Mist extractor manufacturer's recommended minimum distances upstream and downstream of the wire mesh between gas inlet and outlet nozzles should be provided for full utilization of the mist extractor.

C.1.3 The oil capacity of a separator is a function of retention time and gas-oil interface area. The basic requirement is to retain the oil long enough and provide sufficient interface area for entrained gas to break out of the oil. Separator liquid capacity is normally based on one minute retention time for non-foaming oils having a gravity of 35° API and above. A gravity lower than 35° API may require a greater retention time.

C.1.4 Foaming crudes offer a special problem in sizing separators. Foam is a mixture of gas dispersed in a liquid and having a density less than the liquid but greater than the gas. Greater interface area and longer retention time are needed to remove the gas from the liquid. Horizontal separators normally give the largest interface area. Retention times of as high as 15 minutes may be necessary. However, a retention time of 2 to 5 minutes is sufficient in most cases for the separators to handle foaming crudes. Where the well can be sampled in a test unit, a more accurate estimate of the required retention time can be determined. Defoaming separator designs often include a variety of proprietary internal configurations to improve capacity. These are beyond the scope of this specification.

C.1.5 In addition to the well stream properties, the gas capacity is influenced by the following:

a. Operating temperature being above the cloudpoint of oil

b. Operating temperature being above hydrate point of gas

c. Foaming tendency of liquid

d. Uniformity of flow

e. Defoaming chemicals; if used

C.1.6 The liquid capacity of a separator is primarily dependent upon the retention time of the liquid in the vessel. Good separation requires sufficient time to obtain an equilibrium condition between the liquid and gas phase at the temperature and pressure of separation. The liquid capacity of a separator or the settling volume required based on retention can be determined from the following equation:

$$W = \frac{1440\,(V)}{t} \text{ or } t = \frac{1440\,(V)}{W} \text{ or } V = \frac{W\,(t)}{1440}$$

Equation C.1.6

Where: W = Liquid capacity, bbl/day at flowing conditions

V = Liquid settling volume, bbl

t = Retention time, minutes

C.1.7 Basic design criteria for liquid retention time in two-phase separators are generally as follows:

Oil Gravities	Minutes (Typical)
Above 35° API	1
20 — 30° API	1 to 2
10 — 20° API	2 to 4

C.1.8 The settling volumes may be used in the above equations to determine the liquid capacity of a particular vessel. For proper sizing, both the liquid capacity and gas capacity should be determined. It may be noted that on most high pressure gas distillate wells, the gas-oil ratio is high and the gas capacity of a separator is usually the controlling factor. However, the reverse may be true for low pressure separators used on wellstreams with low gas-oil ratios. The liquid discharge or dump valve on the separator should be sized based upon the pressure drop available, the liquid flow rate, and the liquid viscosity.

C.2 Sizing of Three-Phase Gas-Oil-Water Separators — The basic principles of oil and gas separation have been covered under Sizing of Two-Phase Oil-Gas Separators. The following portion will cover the separation of free water and oil:

C.2.1 All of the basic separators (vertical, horizontal, spherical) may be used for three-phase separation. Regardless of shape, all three-phase vessels must meet the following requirements:

a. Liquid must be separated from gas in a primary separating section.

b. Gas velocity must be lowered to allow liquids to drop out.

c. Gas must be scrubbed through an efficient mist extractor.

d. Water and oil must be diverted to a turbulence-free section of the vessel.

e. Liquids must be retained in the vessel long enough to allow separation.

f. The water-oil interface must be maintained.

g. Water and oil must be removed from the vessel at their respective outlets.

C.2.2 Sizing a three-phase separator for water removal is mainly a function of retention time. Required retention time is related to the volume of the vessel, the amount of liquid to be handled, and the relative specific gravities of the water and oil. The effective retention volume in a vessel is that portion of the vessel in which the oil and water remain in contact with one another. As far as oil-water separation is concerned, once either substance leaves the primary liquid section, although it may remain in the vessel in a separate compartment, it cannot be considered as a part of the retention volume. There are two primary considerations in specifying retention time:

a. Oil settling time to allow adequate water removal from oil

b. Water settling time to allow adequate oil removal from water

The usual approach in design is to allow equal retention times for oil and water. This is accomplished with a wide range interface level controller or variable water weir. Basic design criteria for liquid retention time in three-phase separators are generally as follows:

Oil Gravities	Minutes (Typical)
Above 35° API	3 to 5
Below 35° API	
100+°F	5 to 10
80+°F	10 to 20
60+°F	20 to 30

C.3 Separator Selection — The following procedure may be used when selecting a separator for a particular application:

C.3.1 Determine which shape fits the particular installation best considering space, mounting, and ease of access for maintenance. Both present and future operating conditions should be considered.

C.3.2 Determine whether unusual well stream conditions (foam, sand, etc.) would make the vessel selected difficult to operate or maintain.

C.3.3 Determine whether over-all economics is affected by the installation or portability of the shape selected.

C.3.4 Make certain that all design requirements such as heating coils for paraffin or hydrates and three-phasing for water removal have been considered and are compatible with the shape selected.

C.3.5 Consider possible liquid slugging of the separator.

APPENDIX D
SEPARATOR SIZING EXAMPLE CALCULATION

Design Conditions:

Gas flow rate	25 MMSCFD
Oil flow rate	3000 BPD
Operating pressure	800 psig
Operating temperature	80° F
Flowing gas density, d_G (for 20.3 mol. wt. gas)	3.40 lbs/ft³
Flowing oil density, d_L (for 40° API oil)	51.5 lbs/ft³
Separator type	Vertical, two-phase

Tentatively assume 10 feet shell height, 30% liquid full and use K value of 0.3 (see Table C.1 and Equation C.1.1 of Appendix C).

The maximum allowable superficial velocity of the gas is:

$$V_a = K\sqrt{\frac{d_L - d_G}{d_G}} = 0.3\sqrt{\frac{51.5 - 3.4}{3.4}} = 1.128 \text{ ft/sec}$$

Actual volume flow rate of gas =

$$\frac{25{,}000{,}000 \text{ SCF/day} \times 20.3 \text{ lbs/mol}}{379.5 \text{ SCF/mol} \times 86{,}400 \text{ sec/day} \times 3.40 \text{ lbs/ft}^3} = 4.552 \frac{\text{ft}^3}{\text{sec}}$$

$$\text{Min. gas flow area} = \frac{4.552 \text{ ft}^3/\text{sec}}{1.128 \text{ ft/sec}} = 4.035 \text{ ft}^2$$

$$\text{Min. ID of separator} = \sqrt{\frac{4.035 \times 144}{0.7854}} = 27.2 \text{ inches}$$

Use 30 inch ID separator as next largest standard diameter. (Note that 30 inch OD might be preferable, but ID size is used here for simplicity of illustration.) Assume no less than 1 minute retention time for two-phase design with oil gravity exceeding 35° API (equation C.1.6 and Paragraph C.1.7 of Appendix C).

Liquid volume, V (excluding bottom head) =

$$\frac{(30)^2\, 0.7854 \text{ in}^2 \times 3 \text{ feet}}{144 \text{ in}^2/\text{ft}^2 \times 5.615 \text{ ft}^3/\text{bbl}} = 2.62 \text{ Bbls.}$$

The liquid capacity of the separator is:

$$W = \frac{1440\,(V)}{t} = \frac{1440 \times 2.62}{1.0} = 3{,}772 \text{ BPD}$$

Liquid capacity is satisfactory for design based on 30 in. ID × 10 ft. vertical separator size.

APPENDIX E
SEPARATOR DESIGN INFORMATION

I. Operating Conditions:

A. Liquid Volumes

1. Oil/Condensate:_____Barrels/Day Gravity:_____ ° API Viscosity _____ cp
2. Water: _____Barrels/Day Sp. Gr.:_____ (Water = 1.0)

B. Oil/Condensate Characteristics

1. Foaming: Nil_____Moderate_____Severe_____
2. Paraffin Problem: No_____Yes_____ (If Yes, give cloud point)_____°F
3. Slug Flow: No_____Yes_____ (If Yes, give details such as maximum liquid rate, slug volume, etc., or suggest surge factor.) _____

C. Gas:_____MMSCFD Sp. Gr.:_____(Air = 1.0)

D. Operating Temperature (°F):_____Max_____Min

E. Operating Pressure (psig):_____Max_____Min

F. H_2S Content:_____Mole % CO_2 Content:_____Mole %

G. Geographical Location: _____

II. Design Requirements:

A. Type:_____Vertical_____Horizontal_____Spherical

Manufacturer's Recommendation: _____

_____Two-Phase _____Three-Phase

B. Design Pressure:_____psig at Temperature_____°F

C. Type Mist Extractor: (Specify)_____

D. Liquid Retention Time:_____

E. Corrosion Allowance:_____(inches)

F. Corrosion Allowance for Non-Pressure Internal Parts:_____(inches)

G. NACE MR-01-75 Required: No_____ Yes_____

H. Special Stress Relieving: No_____ Yes_____

Specify if Yes: _____

I. API RP 14C Safety Systems Required: No_____ Yes_____

III. Coatings:

A. External: Mfgr. Std._____ Other_____

Specify if Other: _____

B. Internal: (Specify) _____

C. Cathodic Protection: (Specify) _____

IV. Special Instructions:

A. Radiographic Inspection: ASME Code_____ Other_____

Specify if Other: _____

B. Hydrostatic Test Pressure: ASME Code_____ Other_____

Specify if Other: _____

C. Hardness Testing Requirements: (Specify) _____

D. Lifting Lugs: (Specify) _____

E. Skid Mounting: (Specify) _____

F. Welding Requirement: ASME Code_____ Other_____

Specify if Other: _____

G. Sand Removal System: (Specify) _____

H. Other: _____

APPENDIX F
USE OF API MONOGRAM

The API monogram is a registered trademark of the American Petroleum Institute.

Manufacturers desiring to warrant that articles manufactured or sold by them conform with this specification shall obtain the license to use the Official API Monogram.

The original resolutions adopted by the Board of Directors of the American Petroleum Institute on Oct. 20, 1924, embodied the purpose and conditions under which such official monogram may be used.

The following restatement of the resolution was adopted by the Board of Directors on Nov. 14, 1977.

WHEREAS, The Board of Directors of the American Petroleum Institute has caused a review of the Institute's program for licensing the use of the API monogram and

WHEREAS, It now appears desirable to restate and clarify such licensing policy and to confirm and make explicitly clear that it is the licensees, not API, who make the representation and warranty that the equipment or material on which they have affixed the API monogram meets the applicable standards and specifications prescribed by the Institute;

NOW, THEREFORE, BE IT RESOLVED, That the purpose of the voluntary Standardization Program and the Monogram Program of the American Petroleum Institute is to establish a procedure by which purchasers of petroleum equipment and material may identify such equipment and materials as are represented and warranted by the manufacturers thereof to conform to applicable standards and specifications of the American Petroleum Institute; and be it further

RESOLVED, That the previous action under which the following monogram was adopted as the official monogram of the American Petroleum Institute is reaffirmed;

BE IT FURTHER RESOLVED, That the American Petroleum Institute's monogram and standardization programs have been beneficial to the general public as well as the petroleum industry and should be continued and the Secretary is hereby authorized to license the use of the monogram to anyone desiring to do so under such terms and conditions as may be authorized by the Board of Directors of the American Petroleum Institute, provided that the licensee shall agree that the use of the monogram by such licensee shall constitute the licensee's representation and warranty that equipment and materials bearing such monogram complies with the applicable standards and specifications of the American Petroleum Institute; and that licensee shall affix the monogram in the following manner;

BE IT FURTHER RESOLVED, That the words "Official Publication" shall be incorporated with said monogram on all such standards and specifications that may hereafter be adopted and published by the American Petroleum Institute, as follows:

OFFICIAL PUBLICATION

REG. U.S. PATENT OFFICE

F.1 API Monogram. The API monogram — — is a registered trademark/servicemark of the American Petroleum Institute. Authorization to use the monogram is granted by the Institute to qualified licensees for use as a warranty that they have obtained a valid license to use the monogram and that each individual item which bears the monogram conformed, in every detail, with the API Specification applicable at the time of manufacture. However, the American Petroleum Institute does not represent, warrant or guarantee that products bearing the API monogram do in fact conform to the applicable API standard or specification. Such authorization does not include use of the monogram on letterheads or in advertising without the express statement of fact describing the scope of licensee's authorization and further does not include use of the monogram, the name AMERICAN PETROLEUM INSTITUTE or the description "API" in any advertising or otherwise to indicate API approval or endorsement of products.

The formulation and publication of API Specifications and the API monogram program is not intended in any way to inhibit the purchase of products from companies not licensed to use the API monogram.

F.2 Application for Authority to Use Monogram. Manufacturers desiring to warrant that products manufactured by them comply with the requirements of a given API specification may apply for a license to use the monogram with forms provided in an appendix to each specification.

The "Agreement" form must be submitted in duplicate for each specification under which monogram rights are desired. One "Statement of Manufacturer's Qualifications" is required for each facility.

A manufacturer desiring to apply the monogram at more than one facility (a facility is any manufacturing location) must submit a separate application for each facility.

Applicants shall have an approved functioning quality program in conformance with API Spec Q1 prior to being issued a license to use the API monogram.

F.3 Authorization to Use the Monogram. A decision to award or withhold monogram rights will be made by the staff of the Institute. A survey of the applicant's facilities will be made by an approved Institute surveyor prior to a decision to approve or withhold

the license. The basis of the survey shall be the appropriate product Specification and all applicable portions of API Spec Q1.

For a manufacturer having more than one facility (plant), each facility will be judged separately and if determined to be eligible for authorization to use the monogram will be granted a separate license for each Specification, or part thereof, under which authorization is granted. The application of the monogram may not be subcontracted.

F.4 Fee for Use of Monogram.

Initial Authorization Fee. The applicant will be invoiced an initial authorization fee for the first Specification included in the application, and a separate fee for each additional Specification included in the application. The applicant will also be invoiced for the surveyor's fee.

Annual Renewal Fee. In addition to the initial authorization fee, licensees will be assessed an annual renewal fee for each specification under which he is authorized to use the monogram. Applicants issued monogram certificates dated November 1 through December 31 shall not be required to pay a renewal fee for the following year.

The fees assessed are to defray the cost of the Monogram Program.

F.5 Periodic Surveys. Existing licensees must be periodically surveyed by an approved Institute surveyor to determine whether or not they continue to qualify for authorization to use the monogram. The frequency of the periodic surveys will be at the discretion of the staff of the Institute. The surveyor's fee and expenses for making a periodic survey will be paid by the Institute.

F.6 Cancellation of Monogram Rights. The right to use the monogram is subject to cancellation for the following causes:

a. Applying the monogram on any product that does not meet the Specification.

b. Failure to maintain reference master gages in accordance with the Specifications.

c. Failure to meet the requirements of any resurvey.

d. Failure to pay the annual renewal fee for use of the monogram.

e. For any other reason satisfactory to the Executive Committee on Standardization of Oilfield Equipment and Materials.

F.7 Reinstatement of Monogram Rights. Manufacturers whose authorization to use the monogram has been cancelled may request reinstatement at any time. If a request for reinstatement is made within sixty (60) days after cancellation, and if the reason for cancellation has been corrected, no new application is necessary. A resurvey of the manufacturer's facilities will be made by an approved Institute surveyor prior to a decision to reinstate monogram rights. The manufacturer will be invoiced for this resurvey regardless of the Institute's decision on reinstatement. If the resurvey indicates that the manufacturer is qualified, the license will be reissued.

Request for reinstatement made more than sixty (60) days after cancellation shall be treated as a new application unless circumstances dictate an extension of this time period as agreed upon by the API staff.

F.8 Appeals.

An interested party may appeal a decision by the API staff to withhold monogram rights. Appeals shall be directed to the Director, API Production Department and handled by the General Committee of the Production Department with a further right of appeal to the API Management Committee. Competing suppliers or manufacturers of the product or service to which the standard applies or might apply may not be involved in appeals. The General Committee and the Management Committee may convene appeals boards to hear and act on appeals.

F.9 Marking. The following marking requirements apply to licensed manufacturers using the API monogram on products covered by this specification.

F.10 API Nameplate. Separators furnished to this specification shall be identified by a nameplate of corrosion resistant material securely attached to a suitable bracket welded to the shell, or stamped on a steel nameplate seal welded to the shell. The nameplate shall bear the information in items 1 through 10 below, as shown in Figure 6.1.

1. API monogram
2. Spec 12J
3. Manufacturer's name
4. Manufacturer's serial number
5. Year built
6. Weight empty, pounds
7. Shell size, OD × length
8. Maximum allowable working pressure, psi at maximum design temperature, degrees Fahrenheit. Also, minimum temperature if below -20°F.
9. Additional information required by state or other political subdivision regulations.
10. Additional markings desired by the manufacturer or requested by the purchaser are not prohibited.

F.11 ASME Code Nameplate. Separators furnished to this specification shall have a nameplate affixed to the vessel as required by the latest edition of the ASME Code. In lieu of a separate API nameplate and at the discretion of the manufacturer, the information required by Paragraph 6.1 may be included on the ASME Code nameplate.

F.12 Stamping. Stamping directly on the separator shell may be injurious and should be avoided. See ASME Code for allowable stamping.

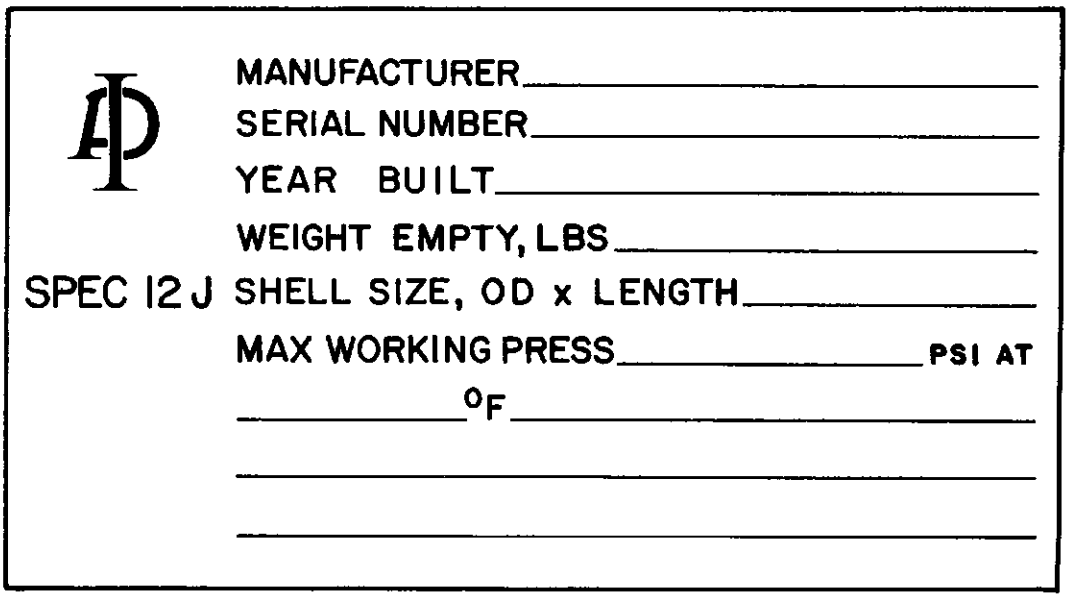


FIGURE F.1
SEPARATOR NAMEPLATE FORMAT
(See Paragraph F.10)

LICENSE AGREEMENT

Use of the Official Monogram of the American Petroleum Institute

This Agreement between the AMERICAN PETROLEUM INSTITUTE (hereinafter "API"), a corporation of the District of Columbia, having an office at 2101 L — Street, N.W., Washington, D.C., and _____, (hereinafter "Licensee"), a corporation of _____, having its principal place of business at _____ provides that:

WHEREAS, API is the owner of federal trademark and servicemark registrations including registration nos. 677,359; 679,642 and 840,642, as well as the owner of common law rights to such trademarks and servicemarks and various other trademarks and servicemarks;

WHEREAS, API through licensing, publications and other programs seeks to establish and promote standards and specifications for goods and services in the petroleum industry;

WHEREAS, Licensee desires a non-exclusive license from API for the purpose of promoting the standards and specifications of API by use of API trademarks or servicemarks on or in connection with the marketing of goods made in accordance with API standards and specifications.

NOW THEREFORE, in consideration of the mutual covenants hereinafter stated, the parties agree as follows:

1. API grants to Licensee a non-exclusive license to use the trademark/service mark API (the "monogram") on products made in accordance with the official publication of API entitled Spec 12J, Specification for Oil and Gas Separators ("the products"), including any amendments, modifications or substitutions that may hereafter be adopted.

2. API grants to Licensee a non-exclusive license to use the monogram in connection with the marketing of the products; provided, however, that Licensee shall not use the monogram on letterheads or in any advertising without an express statement of fact describing the scope of Licensee's authorization, and further provided that Licensee shall not use the monogram or the name the AMERICAN PETROLEUM INSTITUTE or the description "API" in any advertising or otherwise to indicate API approval or endorsement of the products.

3. Licensee agrees that it will do all acts required of it by API to ensure that pertinent API standards and specifications are being met at all times in the manufacture of the products, including submitting when requested by API a statement of manufacturer's qualifications and samples of the products and permitting API, or a representative thereof, upon reasonable notice to inspect pertinent manufacturing facilities. API shall be the sole judge of whether Licensee meets the appropriate qualifications to become and remain a licensee and whether the products meet the appropriate qualifications.

4. Licensee agrees that use of the monogram on the products shall constitute a representation and warranty by Licensee to API and to the purchasers of the products that the products conform to the applicable standards and specifications of API; and Licensee agrees to hold harmless and indemnify API for any and all liability, loss, damage, cost and expense which API may suffer, incur, or be put to by reason of any claim, suit or proceeding, for personal injury, property damage or economic loss based on the failure or alleged failure of the Licensee's products to conform to such standards and specifications; and Licensee further agrees to defend API, at Licensee's expense, against any and all such suits, claims or proceedings.

5. This license shall not be assignable or transferable by Licensee in any manner nor shall Licensee have the right to grant sublicenses.

6. This Agreement may be terminated at any time and for any reason satisfactory to the API.

7. This license shall run from year to year and shall be renewed yearly upon payment by Licensee to API of an annual renewal fee.

_____
(Licensee Company Name)

Date: _____ By _____

Effective
Date: _____ AMERICAN PETROLEUM INSTITUTE

By _____

AMERICAN PETROLEUM INSTITUTE

PRODUCTION DEPARTMENT
2535 ONE MAIN PLACE
DALLAS TX 75202-3904

STATEMENT OF MANUFACTURER'S QUALIFICATIONS TO USE API MONOGRAM

The information indicated below, when requested by the Institute, must accompany all applications to use the API monogram. All such information is subject to investigation and applications must be rejected if the information supplied so warrants.

Material: _____
(List here the equipment on which applicant desires to apply the monogram)

API specification designation: _____

1. Name of applicant: _____
2. Location of principal office: _____
3. Where will equipment be manufactured? _____
4. Class of ownership: _____
(Corporation, partnership, or individual)
5. Capital invested: _____ 6. Year organized: _____
7. Is the applicant thoroughly familiar with all stipulations given in the API specification covering this material? _____
8. Is the applicant actually manufacturing this material now? _____
   a. State the length of time applicant has made the material and supplied it to the oil industry: _____
   (Years and Months)
   b. State the approximate percentage of production of this material to applicant's total production: _____
9. Give the names and addresses of five representative users in the oil industry to whom applicant has sold this material (give name of company, complete street address, and name of company representatives to whom inquiries should be addressed):

_____
_____
_____
_____
_____
_____
_____
_____

10. If applicant has not supplied this material to the oil industry and cannot furnish the five references under item 9, give the names and addresses of five representative users in other industries to whom applicant has sold similar equipment (give name of company, complete street address, and name of company representative to whom inquiries should be addressed):

_____

_____

_____

_____

_____

_____

11. If the applicant is not now manufacturing this material, when does he expect to begin production? _____

_____

12. If the applicant has not previously made this material, state fully (on an attached sheet) the experience of any members of applicant's present organization in the manufacture of this material, giving names of organizations where such experience was obtained.

Questions 13, 14, 15, and 16 need be answered only if the specification requires testing or ASME Code design, fabrication, inspection, and stamp.

13. Does the applicant now possess the necessary equipment and personnel for conducting all tests required in the API specification covering this material? _____

14. Does the applicant now hold a valid Certificate of Authorization from the Boiler & Pressure Vessel Committee of the American Society of Mechanical Engineers to use the "U" Pressure Vessel symbol as required by Section VIII, Division 1? _____

15. Applicant's Certificate of Authorization Number is _____ which expires on _____.

16. Does applicant agree to notify API in the event the applicant ceases to hold a valid Certificate of Authorization for any reason? _____

17. Give names of five responsible business men as references regarding applicant's general character, integrity, and reputation. (Give complete mailing address and name of organization with which each is affiliated.)

_____

_____

_____

_____

_____

18. Name and address of applicant's representative to whom API correspondence should be directed:

_____

_____

(Signature and title of authorized officer)

Date _____

_____

(Name of organization, company, or individual)

(The above statement to be signed in the name of the applicant by an authorized officer)

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