SPECIFICATIONS AND QUALIFICATION PROCEDURES FOR AVIATION FUEL FILTER MONITORS WITH ABSORBENT TYPE ELEMENTS

API/IP SPECIFICATION 1583

Third edition
November 2000

IP THE INSTITUTE OF PETROLEUM

American Petroleum Institute

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FOREWORD

This publication, which has been prepared jointly by the Institute of Petroleum Aviation Committee and the American Petroleum Institute Aviation Technical Services Sub-Committee, is intended to provide the industry with comprehensive specifications and qualification test procedures for filter monitors with absorbent type elements suitable for use in aviation fuel handling systems.

These specifications are for the convenience of purchasers in ordering, and manufacturers in fabricating, filter monitor vessels and elements of the absorbent type. They are not in any way intended to prohibit either the purchase or manufacture of filter monitors meeting other requirements.

Any manufacturer wishing to offer filter monitors conforming to these specifications is responsible for complying with all the mandatory provisions of these specifications, plus any optional provisions requested by the purchaser.

The purchaser may make any investigations considered necessary to confirm that the manufacturer has conformed to these specifications. The purchaser is recommended to exercise this right by inspecting equipment independently of any supervisory inspection furnished by the manufacturer.

Once vessel and element approvals have been granted by a purchaser, no design or materials changes are to be made by the manufacturer without first seeking the purchaser's prior approval. The purchaser will then have the right to insist on a partial or complete retest of the filter monitor by the manufacturer to confirm its performance still complies with these specifications. Purchasers may also request partial or complete retests should they have reasonable grounds for believing the performance of filter monitor elements has deteriorated from the original test standard.

It is anticipated that purchasers may wish to install absorbent type filter monitor elements in vessels originally [redacted]

ACKNOWLEDGEMENTS

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Draft versions of this third edition were reviewed by representatives of the following companies:

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GENERAL

1.1 SCOPE

This publication covers the recommended minimum performance and mechanical specifications for filter monitor equipment and the recommended testing and qualification procedures.

This publication refers specifically to the use of elements of 50 mm (2 inch) and 150 mm (6 inch) nominal diameters.

The specifications do not cover trigger type monitor elements.

The specifications do not cover the operation and performance of this type of equipment in fuels containing Fuel System Icing Inhibitor (FSII). This fuel additive is unique and makes unusually difficult demands on filtration and water separation/removal devices. Operators using such additives in aviation fuels are recommended to ensure for themselves the performance capabilities of filtration equipment by contacting the filter manufacturer for such information.

Note 1: Performance testing of elements of different nominal diameters is outside the scope of this specification. However the test principles described in this document may be adapted to apply to such elements and it is the responsibility of the manufacturer to adjust test parameters accordingly.

Note 2: The document uses S.I. units throughout except where there is no practical conversion equivalent. Where appropriate, alternative units in common usage are given in brackets. Section 4.7 lists the unit conversion factors used in this specification.

1.2 DISCLAIMER

The inclusion of additive packages in this specification is for testing purposes only and does not constitute acceptance or rejection of these additives in jet fuels.

1.3 SAFETY PRECAUTIONS

It has been assumed by the specification writers that all users of this specification will, if not themselves fully trained, at least be under the supervision of a responsible trained person who will be familiar with all normal laboratory and engineering safety practice, and that all such precautions will be observed. It is the responsibility of users of the specification to ensure that the requirements of locally prevailing health and safety legislation are fully complied with.

1.4 REFERENCED PUBLICATIONS

The following publications are cited in this publication, the latest available edition of each referenced publication applies.

IP

IP 216 *Determination of particulate contaminant of aviation turbine fuels by line sampling (ASTM D 2276)*

IP 274 *Petroleum products - Aviation and distillate fuels - Determination of electrical conductivity (ISO 6297)*
IP 452 *Determination of the water shedding property (WASP) of aviation kerosine*

ASME[1]
Boiler and pressure vessel code, Section VIII: Rules for construction of boilers and pressure vessels

ASTM[2]
D 156 *Test method for saybolt colour of petroleum products (Saybolt chromometer method)*
D 381 *Test method for existent gum in fuels by jet evaporation*
D 1094 *Test method for water reaction of aviation fuels*
D 1655 *Specification for aviation turbine fuels*
D 2624 *Test method for electrical conductivity of aviation and distillate fuels containing a static dissipater additive*
D 3240 *Test method for undissolved water in aviation fuels*
D 3948 *Test method for determining water separation characteristics of aviation tubine fuels by portable separometer*

MoD[3]
Defence Standard 91-91/Issue 3 *Turbine fuel, aviation kerosine type, Jet A-1 NATO Code: F-35, Joint service designation: AVTUR* (DERD 2494)

JIG[4]
AFQRJOS *Aviation fuel quality requirements for joint operating systems*

US Military[5]
MIL-I-25017 *Inhibitor, corrosion (for aircraft engine fuels)*

1.5 ABBREVIATIONS

The following abbreviations are used within this publication:

cu	conductivity unit
FSII	fuel system icing inhibitor
gal.	gallon
gpm	US gallons per minute
kPa	kilopascal
lbf/in^2	pound per square inch
litres/sec/m	litres per second per metre length
mg	milligram
mm	millimetre
mN/m	millinewtons per metre
ppmv	parts per million by volume
pS/m	picosiemens per metre
Ra	arithmetical mean deviation of an assessed profile
RPM	revolutions per minute
SC	solids content
ST	surface tension
TIR	total indicator reading

1.6 DESCRIPTION

1.6.1 Principles

For the purposes of this specification, a filter monitor is defined as a vessel containing water absorbent filter elements that will continuously remove dirt and water from aviation fuels down to a level acceptable for servicing modern aircraft. It will positively shut off the flow if the concentration of water or dirt is unacceptable. Filter monitors can be of a vertical or horizontal orientation.

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1 American Society of Mechanical Engineers, 3 Park Avenue, New York, New York 10016-5990. www.asme.org
2 American Society for Testing and Materials, 100 Barr Harbour Drive, West Conshohocken, Pennsylvania 19428, USA. www.astm.org
3 Ministry of Defence Directorate of Standardization, Room 1138, Kentigern House, 65 Brown Street, Glasgow G2 8EX, UK. www.dstan.mod.uk
4 Joint Inspection Group, c/o 35 Abercorn Place, London, NW8 9DR, UK.
5 US Military, Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120, USA.

1.6.2 Performance features

A filter monitor shall have the following general features:

(a) It shall ensure effluent contamination levels are not in excess of the limits given in section 1.6.3 throughout its operational life.

(b) It shall monitor the full flowing stream and may include a fail-safe feature to prevent unmonitored fuel from bypassing the elements.

(c) It shall require no external power supply.

(d) It shall be simple, strong, compact and easy to install and service.

(e) It shall not contaminate the fuel and fuel properties shall remain within the prescribed limits of the relevant fuel specification.

(f) When triggered by a water slug the total fluid leakage through the device shall not exceed 1 % of the rated flow of the device.

1.6.3 Performance specifications

1.6.3.1 Effluent fuel contamination limits
Determined from samples taken during the qualification test procedures, and analysed by the specified methods therein, the effluent fuel contamination shall not exceed:

Total solids[6]	-	0.26 mg/litre (1.0 mg/U.S. gal.) average
	-	0.5 mg/litre (1.9 mg/U.S. gal.) maximum
Free water	-	15 ppmv
Media migration[7]	-	10 fibres/litre
Appearance	-	the effluent fuel shall be clear and bright.

1.6.3.2 Flow rate
Two inch nominal diameter elements shall meet the performance specifications at a nominal flow rate (see section 2.1.1) of 2.5 litres/sec/m (1.0 gpm/inch length).

Six inch nominal diameter elements shall meet the performance specification at a nominal flow rate of 10 litres/sec/m (4.0 gpm/inch length).

More specifically, the flow rates for any length of element shall meet the effective flow rate criteria described in section 4.2.

1.6.3.3 Solids holding capacity
The solids holding capacity is measured as the time taken for an element to reach 1.5 bar pressure differential at full rated flow with an influent solids addition rate of 10 mg/litre.

— Blocking time for 50 mm (2 inch) nominal diameter elements - at least ten minutes.
— Blocking time for 150 mm (6 inch) nominal diameter elements - at least fifty minutes.

1.6.3.4 Water holding capacity
The water holding capacity is measured as the time taken for the element to reach 1.5 bar pressure differential at full rated flow with a water addition rate of 50 ppmv.

— Blocking time for 50 mm (2 inch) nominal diameter elements - at least ten minutes
— Blocking time for 150 mm (6 inch) nominal diameter elements - at least forty minutes

1.6.3.5 Water slug test
A water slug is defined as a volume of water equivalent to at least 1 % of element or vessel rated flow per minute or equivalent to at least the water holding capacity of the element(s). When subjected to a water slug, the element(s) shall effectively shut down flow in accordance with section 1.6.2.

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6 The average total solids in the effluent fuel will be the arithmetic average for each run calculated from the total solids passed and the total sample volume. No individual sample shall exceed 0.5 mg/litre. If a sample is being taken when an element reaches the differential pressure at which the test run should stop, sampling may be discontinued immediately and where possible the pro-rated result should be calculated and included in determining the average.

7 Any particle in the effluent having a length to diameter ratio of 10 to 1 or more and having a length of 100 microns or more, shall be counted as a fibre from the elements. The maximum number of such fibres permissible in the effluent is 10/litre of fuel. Also, the effluent fuel shall be clear and bright.

1.6.3.6 Pressure differential
The differential pressure across a vessel having new elements operating at rated flow with clean and dry fuel shall not exceed 0.55 bar.

1.6.3.7 Element structural strength
The element shall be capable of withstanding a maximum differential pressure of 12 bar for five minutes without structural failure. Deformation of the element shall not prevent the monitor shutting down and stopping the flow.

1.6.3.8 Effluent fuel conductivity requirement
When tested in fuel containing Additive I (in accordance with Section 2) the minimum effluent fuel conductivity shall be >50 pS/m. The term conductivity unit (cu) is equivalent to pS/m.

1.7 PRODUCT QUALITY ASSURANCE

A product quality assurance programme shall be adopted by the manufacturer. As a minimum, the programme shall include the annual testing of each qualified element type using the mandatory single element test protocols included in this publication. The test results shall be filed with the results of the qualification tests and be made available to the purchaser if requested.

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FILTER MONITOR ELEMENTS

2.1 MECHANICAL SPECIFICATIONS

2.1.1 Element dimensions

2.1.1.1 Element length

The **nominal length** of an element is the quoted overall length of the element from end-cap shoulder to end-cap shoulder. The **effective length** of an element is the actual media length exposed to fuel flow.

For 50 mm (2 inch) diameter elements the nominal length shall have a tolerance within the limits +/- 1.5 mm.

For 50 mm (2 inch) diameter elements which include a mounting spigot, the overall length (including the spigot) shall be the nominal length + 14 mm (with a tolerance within the limits - 0.6/+ 0.3 mm).

2.1.1.2 End cap dimensions

End caps shall conform to the dimensions contained in Table 1.

2.1.2 Element design and construction

2.1.2.1 Element sealing

Element seals, to suit the mounting arrangement according to 3.1.2.9.1 or 3.1.2.9.2 as appropriate, should not allow bypassing at a differential pressure of 1552 kPa when applied in the flow direction. Care shall also be taken to ensure that "Knife" edges do not cut gasket surfaces. Providing a narrow flat area at the apex of the "Vee" is one solution.

2.1.2.2 Element construction materials

All metal parts in contact with the fuel shall be free of zinc, cadmium and copper. Metal components of elements shall be non-corroding. All materials shall be chemically compatible with the fuel. All seals shall be Viton A, or Buna N, or equivalent.

Table 1 End cap dimensions

	minimum	maximum
Outer diameter	-	45mm
Support hole diameter	8.2 mm	12.7 mm
Support hole parallel depth	18.5 mm	-
Support taper recess, outer diameter	31.5 mm	32.7 mm
Support taper recess, slope relative to end face	23°	30°

2.1.2.3 Element identification

Each individual element shall be permanently marked to indicate its model number, and date of manufacture. Materials used to so identify the elements shall not contribute to contamination of, nor be affected by, aviation fuels. Where the element type can have alternative flow directions (e.g. 150 mm (6 inch) diameter elements can be in-to-out or out-to-in), the direction of flow shall be indicated on the end cap (on the gasket for open-ended elements).

2.1.2.4 Element packaging

Elements shall be packed for shipment to guard against damage by crushing and individually protected against contamination by dirt and/or moisture with a polyethylene bag or similar wrapping.

Included in the packaging shall be information and advice to the purchaser on matters such as:

(a) handling and installation including recommended torque for element installation,
(b) guidance on waste element disposal,
(c) contact point for quality complaints,
(d) recommended storage conditions and periods.

2.2 TEST PROCEDURES

2.2.1 General

[redacted]

2.2.1.3 Element requirements

For 50 mm (2 inch) nominal diameter elements, the maximum length of element from the manufacturer's range shall be tested. See section 4.2 for the qualification of other lengths of element by similarity.

For 150 mm (6 inch) nominal diameter elements, the length of the test element will depend on the range of lengths required to qualify by similarity (see section 4.2).

Both nominal and effective lengths and the nominal flow rate and flow rate per effective media length shall be quoted in all qualification test documents.

In the event of an element type being produced in both screw-based and open-ended formats, the longest manufactured length of the screw-based element shall be submitted for the structural tests. The open-ended format will then be covered by the screw-based qualification.

2.2.1.4 Test schedule

A schedule of the tests required is given in section 4.5.

2.2.2 Witnessing

In reporting the results of the following tests, all data arising from witnessed tests shall be included. Any test failures or anomalous results shall be investigated with the witness(es). The report shall indicate the nature of the problem that occurred and the solution adopted. The [redacted]

2.2.4 Preparation for performance testing

2.2.4.1 Test vessel preparation
The test vessel shall be examined to determine the condition of the internal surface finish and the uniformity and condition of any lining material used.

2.2.4.2 Test element preparation
A full set of elements shall be critically examined before installation and any having visual defects shall be rejected and noted. A test element shall then be installed in the test vessel according to the manufacturer's instructions, with a note being made of the ease of assembly, security of elements and sealing methods. The design shall be such as to minimise the possibility of mal-assembly.

2.2.4.3 Test fuel preparation
The test fuel shall be cleaned by pumping it through the test rig, bypassing the test position but including the clay treaters and clean-up vessel (filter-water separators). Pumping shall be continued until all additives have been removed. A maximum conductivity of 10 pS/m will indicate that all anti-static additive has been removed. The fuel shall then be treated with the additive package listed in 4.1.4 in accordance with the procedure in 2.2.4.4. The test vessel shall then be slowly filled with fuel. Any leaks shall be noted and eliminated. During the filling operation there shall be no appreciable fuel flow out of the test vessel.

The fuel shall be sampled from the test vessel feed sample point for fuel quality checks. The water separation character (by either IP 452 or ASTM D 3948) and the conductivity (IP 274 or ASTM D 2624) of the fuel shall be measured on samples taken before and after treatment.

2.2.4.4 Additive additions
Unless specified otherwise in 2.2.5, performance testing requires the addition of three additives to the test fuel. The additives are described in 4.1.4.

Additive I shall be added to the fuel at a concentration of 1.0 mg/litre. The fuel shall be circulated through the test facility, bypassing the test vessel and other filtration until the system is stabilised; i.e. three successive conductivity measurements taken five minutes apart are within ±10 pS/m.

Additive II shall be added to the test fuel at a concentration of 2.9 mg/litre with continued circulation of the fuel, bypassing the test unit and all other filtration until the system has again stabilised; i.e. three successive conductivity measurements are within ±10 pS/m.

Additive III shall be added to the test fuel at a concentration of 0.4 mg/litre with continued circulation of the fuel, bypassing the test unit and all other filtration until the system has again stabilised; i.e. three successive conductivity measurements are within ±10 pS/m.

No further addition of any of the above additives shall be made during any test run.

Additives I, II and III may be added one after the other, but not as a fully blended concentrate. The fuel shall be circulated through the test facility, bypassing the test vessel and other filtration until the system is stabilised; i.e. three successive conductivity measurements taken five minutes apart are within ±10 pS/m. This will save time but witnesses should pay particular attention to the results of subsequent conductivity and water separation analyses.

2.2.5 Mandatory performance tests

2.2.5.1 Run 1 Media migration and differential pressure test
Clean dry test fuel containing the additive packages is pumped through the test unit at its rated flow. Immediately after pumping is commenced an effluent fuel sample shall be taken as described in IP 216 (ASTM D 2276). A sample volume of 5 litres is required. Pumping is continued for 30 minutes and a second 5 litre fuel sample is then taken.

At the end of the media migration test, the differential pressure at rated flow is measured and recorded. The media migration samples shall be analysed as described in section 4.3.

Fuel samples shall be taken from the test unit effluent at start and end of test for water separation and conductivity measurements.

2.2.5.2 Run 2 50 ppm water test, full rated flow
The element used in Run 1 may be used or a new element installed. Fuel is pumped through the test unit at its rated flow and water is injected into the centre of the fuel stream immediately before the rig pump, at a rate calculated to give 50 parts per million of free water by volume dispersed in the fuel. The test is continued until a differential pressure of 3 bar is achieved. During the test, the following test procedures are to be followed.

Effluent samples are taken at the beginning of the run and analysed for conductivity and water separation.

After three minutes of testing the pressure differential is recorded and a stop/start[8] procedure performed. A second similar stop/start cycle shall be carried out when the differential pressure has reached 1 bar (15 lbf/in^2).

After the stop/start, once steady flow is re-established, the pressure differential is again recorded and the effluent from the unit is sampled for free water content by Aqua-Glo (ASTM D 3240). The sampling procedure for this shall be by opening fully the effluent sample valve immediately before restarting the flow and leaving it open until the required volume has passed through the Aqua-Glo monitor.

The effluent from the unit is also periodically sampled for free water content by Aqua-Glo at two minutes, three minutes (stop/start) then every ten minutes thereafter, in addition to that taken at the start up following the 1.0 bar stop/start cycle.

The fuel temperature and the pressure differential across the unit are also noted at the instant of sampling and the total water added during the test is recorded.

2.2.5.3 Run 3 Water slug test, full rated flow

This test is carried out with a new element. Fuel[9] is pumped through the test unit at its rated flow and a neat water slug is introduced into the fuel. The minimum volume of water used shall be equivalent to 1 litre/100 litres/minute of element rating or equivalent to the water holding capacity of the element(s) (whichever is the greater). The maximum volume of water used shall be the above volume together with an amount equivalent to the volume of pipework between the water slug injection point and the test vessel plus the test vessel volume upstream of the elements. Following its introduction, the water slug shall then be backed by fuel again.

The test procedure is as follows:

(a) Circulate clean, dry fuel through the test vessel and element at full rated flow, taking suction from the fuel tank.

(b) With the pump kept running, smoothly introduce the water slug either upstream of the pump by drawing water from a tank containing the requisite volume of water topped up with test fuel (pulling the water slug into the system) or downstream of the pump by diverting the fuel flow through a side tube containing the requisite volume of water (pushing the water slug into the system).

(c) Continue the test until the pressure differential reaches pump stall (see 4.1.1.3).

The pump stall pressure shall be maintained for five minutes and the effluent from the test unit collected in separate graduated containers, one container for each minute of effluent monitoring. The volume of water collected for each minute shall be noted and reported.

The leak rate of effluent through the element shall not exceed 1 % of the rated flow at any time. To accomplish this part of the test a shut off valve will be required immediately downstream of the test vessel. The effluent may be allowed to drain through a probe sample port or through a drain port on the downstream side of the test vessel.

Note: The initial five seconds-worth of leak-by fluid may be discarded as this is usually unrepresentative of the leakage process being the result of the system depressurising.

2.2.5.4 Run 4 Mechanical integrity of saturated element test

This test is performed on the same element used in Run 3, if the pump stall pressure was less than 12 bar.

At the end of Run 3 the line pressure is increased until a pressure differential of 12 bar is reached across the element, or until obvious failure occurs, whichever is the sooner. This pressure shall be maintained for five minutes. If failure occurs the pressure differential at which the element broke down is noted.

On removal of the element from the test vessel, any signs of absorbent media extrusion through the element casing and/or any changes to the shape of the element, rupture of the element, etc. shall be noted and reported.

8 A stop/start is an interruption of flow accomplished by shutting, in approximately four seconds, a quick-closing valve located downstream from the effluent sampling connection. The flow is then re-established and the test continued. Prior to starting the stop/start procedure, water or solids injection points should be isolated. These are re-opened immediately after re-establishing flow.

9 Clay-treated non-additivated fuel may be used for this and other water slug tests.

2.2.5.5 Run 5 Water slug test, 10 % rated flow

This test is carried out with a new element. Fuel is pumped through the test unit at 10 % of the rated flow of the element and a neat water slug with a volume as specified in section 2.2.5.3 is introduced into the fuel. The test is performed in the same way as in Run 3 but the low fuel flow rate of 10 % element rated flow is used.

2.2.5.6 Run 6 Solids test

This test is carried out with a new element. Fuel is pumped through the unit at its rated flow, and solid contaminant is injected into the fuel in sufficient quantity to result in a solids contaminant level of 10 mg per litre of fuel. At the start of the test feed, samples of fuel shall be taken upstream of the contaminant injection points for water separation and conductivity measurements. The effluent from the test unit is sampled at five minutes (stop/start) and every ten minutes thereafter until a differential pressure of 1.5 bar is recorded.

These samples are analysed for solids content in accordance with IP 216 (ASTM D 2276).

The fuel temperature and the pressure differential across the unit are noted at the time of sampling.

Note: After five minutes of testing the pressure differential is noted and a stop/start sequence carried out as described in 2.2.5.2.

The sampling procedure shall be to fully open the sample valve immediately before restarting the flow and leave it open until the required volume has passed through the direct gravimetric monitor.

A second similar stop/start cycle shall be carried out when the differential pressure has reached 1.0 bar (15 lbf/in^2).

2.2.5.7 Run 7 Mechanical integrity of solids contaminated element

This test is carried out on the same elements as used in Run 6 in a suitable test facility. Solid contaminant is fed to the unit in fuel[10] until either a pressure differential of 12 bar across the unit is reached or until obvious failure occurs, whichever is the sooner. If failure occurs, the pressure differential at which the element breaks down is noted. The maximum test pressure of 12 bar shall be maintained for a period of five minutes.

On removal of the element from the test vessel, any signs of absorbent media extrusion through the element casing and/or any changes to the shape of the element, rupture of the element, etc. shall be noted and reported.

2.2.5.8 Run 8 Freeze/thaw tests

An element of normal production shall be tested under the same conditions as in Run 2 until the differential pressure reaches 1.0 bar. It is not necessary in the preconditioning stage of the test to carry out the stop/start sequences.

The element shall then be removed from the test vessel and immediately placed in a bath of cold fuel at a temperature of minus 40°C or below for 24 hours. After this time the element is removed from the cold fuel and allowed to return to room or ambient temperature.

The element shall then be replaced in the single element test vessel and the test conditions and requirements of Run 2 continued until completion. The element shall then be subjected to the conditions and requirements of Run 3 (including water saturation).

2.2.5.9 Run 9 Full water immersion tests

A new element is to be fully immersed in water for a minimum time of ten hours. The element is removed from the water and visually assessed. Any evidence of bulging, rupture or media extrusion shall be noted and reported. It is then installed in the test vessel and exposed to at least 5 bar pressure by flowing fuel[11] through the vessel. The effluent fuel shall be monitored as in Run 3.

2.2.5.10 Run 10 Partial water immersion tests

Another new element is firstly fuel wetted and then immersed in water to a depth of 25-30 % of the total media length for a minimum time of one hour. The water level shall be maintained by topping up and the downstream side of the element protected from direct exposure to the water. The element is removed from the water and visually assessed. Any evidence of bulging, rupture or media extrusion shall be noted and reported. It is then installed in the test vessel and subjected to rated flow of fuel. The orientation of the element shall be such that the fuel flows past the wetted part of the element (e.g. for an out-to-in element the wetted part of

10 Any appropriate fluid may be used for this and other mechanical integrity tests. Influent solids content may exceed 10 mg/litre in mechanical integrity tests.

11 Clay-treated non-additivated fuel may be used for this and other water slug tests.

the element shall be mounted nearest to the vessel outlet). The pressure differential is recorded and downstream Aqua-Glo and media migration samples taken immediately after the fuel flow has been established and five minutes later. Water transmission and media migration shall be within the limits described in 1.6.3 and the effluent fuel shall appear clear and bright.

2.2.5.11 Run 11 Compatibility tests

New elements are soaked for 336 hours in each of the test fluids listed in section 4.4. Details of the test schedules for each of the fluids are also given in 4.4. For each test the volume of fluid required shall be equal to 5 times the volume of a solid having the same outside dimensions as the test element or piece of test element. For 50 mm (2 inch) diameter elements, 250 mm (10 inch) long versions may be used. For 150 mm (6 inch) diameter elements 14 inch long "half-elements" (prepared by sectioning along the longitudinal axis) may be used.

These tests are performed only once.

To avoid error or ambiguity the containers used in these tests shall:

(a) be identical and have non-contaminating sealable lids or caps,

(b) be of such dimensions that the test specimen can be totally immersed in the test fluid,

(c) be inert to the test fluids (e.g. amber glass, aluminium or stainless steel containers would be suitable). Since the test fluids will be light sensitive, it is recommended that during the soak period, the containers be kept in a dark enclosure. For reference one litre samples of each of the test fluids shall be stored in containers similar to those used in the compatibility tests.

Before commencing the test the containers shall be thoroughly rinsed with the respective test fluid.

Results shall be reported in a form similar to that shown in 4.4.2 together with copies of full refinery release certificates for the jet fuel. Note that the reference sample is analysed at the start and end of the test period. Additional testing followed by field service evaluations shall be necessary if any one of the following results is obtained:

(a) MSEP falls below 85 or WASP (IP 452) > 650,

(b) the difference in existent gum between blank run and element run is > 8 mg/100cm^3. (Note that if the difference between the initial blank and the blank after 336 hours is > 8 mg/100cm^3 then the whole compatibilty test run shall be repeated using different containers),

(c) the water reaction interface rating is > 1b,

(d) there is any visually detectable change in the test element,

(e) the colour decreases by more than four units compared to the blank measured after the same time as the soak period.

2.2.5.12 Run 12 50 ppmv water test, low flow

A new element is installed in a test vessel. Non-additivated, clay-treated fuel shall be used for this test. Recirculation is permitted.

The test is conducted at 10 % of the rated flow of the test element. 50 ppmv water is introduced into the influent fuel in the manner described previously in this specification. There are no stop/start sequences in this test run. Effluent fuel shall be tested for free water (Aqua-Glo) hourly and for media migration (IP 216) every two hours. The run shall be continued until the element differential pressure reaches 1.0 bar (15 psi). (Note: This may take several days and so the test run may have to be suspended each evening and restarted each morning.) The effluent quality shall meet the performance requirements of Section 1.

2.2.5.13 Run 13 Full-scale vessel water test

A recirculating fuel system containing Additive I only may be used. The equilibrium fuel conductivity shall be maintained throughout the test by further additive injection as required. Run 2 conditions shall then be used for the test on a full scale filter monitor vessel with all elements installed. The minimum flow rate for the vessel shall be 300 gpm.

2.2.5.14 Run 14 Full-scale vessel water slug test

A water slug test as described in Run 3 is performed on the full scale vessel with all elements in place as described in Run 13. Fuel for this test may be as described in either 2.2.4.3 or 2.2.5.13.

2.2.6 Optional performance tests

2.2.6.1 General

These performance tests are optional and need only be performed if requested by the purchaser.

2.2.6.2 Run 15 50 ppmv water test, short element lengths

The conditions of Run 2 shall be used at the effective flow rate calculated as described in section 4.2.

2.2.6.3 Run 16 50 ppmv sea water test

For this test the conditions of Run 2 are applied but the water is replaced by a synthetic sea water solution[12].

12 ASTM lists a recognised synthetic sea water composition and many chemical drug houses supply suitable preparations.

3

FILTER MONITOR VESSELS

3.1 MECHANICAL SPECIFICATIONS FOR VESSELS (50 mm (2 inch) and 150 mm (6 inch) nominal diameter elements only)

3.1.1 General

Approval of the mechanical design of a unit is the responsibility of the purchaser. The purchaser should obtain assurance from the supplier in respect of the vessel's performance and design features covered in this section.

Performance qualification of vessels is not a requirement of this specification, however, if the purchaser requires a specific vessel test, a suitable protocol is given in Section 2.

3.1.2 Vessel design

3.1.2.1 Design codes

Filter monitor vessels shall be designed and constructed to conform to the latest issue of the ASME *Boiler and pressure vessel code, Section VIII: Rules for construction of boilers and pressure vessels*, or other recognised pressure vessel code agreed by the purchaser.

3.1.2.2 Design pressure

Unless otherwise specified by the purchaser a minimum vessel design pressure of 1035 kPa (150lbf/in^2) is required.

3.1.2.3 Hydrostatic test pressure

For hydrant dispensers and refuellers each filter monitor vessel body shall be hydrostatically tested to 1552 kPa (225 lbf/in^2) or 1.5 times the design pressure specified by the purchaser. A hydrostatic test of 1552 kPa (225 lbf/in^2) shall also be applied to the upstream side of the division plate with all non-return valves closed or all element entry ports sealed.

For other applications the purchaser should specify this parameter to the manufacturer.

3.1.2.4 Piping connections

All main fuel piping connections larger than 38 mm (1.5 inch) nominal bore shall have a pressure rating equal to or greater than that of the vessel and should be flanged. Connection types other than flanged may be used if specifically requested by the purchaser.

Note: Fire safety issues should be considered when specifying connections.

Unless the inlet connection leads to a free area inside the vessel, elements shall be shielded by use of a baffle or other means to avoid damage by the impact of flow velocity.

3.1.2.5 Ports and connections

Ports shall be female threaded or flanged according to customer request.

Note: Male threaded stubs welded to the vessel are not acceptable for attachment of small valves and fittings since they are more susceptible to damage during shipping and handling.

Ports which have a parallel thread should have smooth external face and dimensions suitable for fittings with an integral O-ring face seal and those utilising bonded sealing washers e.g. Dowty and Stat-O-Seal types.

Weld beads on vertically installed half couplings or pipe stubs should not protrude internally and cause localised entrapment of contamination.

3.1.2.6 Vent and pressure relief ports

A connection shall be provided at the highest fuel flow point of the inlet and/or outlet chamber as appropriate for installation of an air eliminator. Provision for a pressure relief valve shall also be made.

3.1.2.7 Pressure ports

Ports shall be provided for connecting appropriate pressure gauges to the filter monitor to read differential pressure between the inlet and outlet piping connections.

3.1.2.8 Element spacing

Element-element and element-vessel wall contact shall be avoided. The design layout of elements in the vessel shall provide a minimum distance of 6.4 mm (0.25 inch) between 50 mm diameter elements and 12.7 mm (0.5 inch) between 150 mm diameter elements. These dimensions also apply between the elements and the vessel wall.

3.1.2.9 Element mounting

3.1.2.9.1 50 mm (2 inch) diameter elements

The sealing bore for vessels using 50 mm (2 inch) diameter elements shall be 33.30 mm to 33.40 mm (1.311 to 1.315 inches) diameter, with a surface finish better than 3 µm Ra.

A lead in angle shall be provided of 10° to 20° from a diameter 1.5 mm (0.060 inch) larger than the bore size.

Out of roundness shall not exceed 0.025 mm (0.001 inch) total indicator reading (TIR).

3.1.2.9.2 150 mm (6 inch) diameter elements

For vessels designed to accept elements with flat end gaskets (face seal), the mounting surface should incorporate a blunted V-shaped knife edge approximately 1.5 mm high (0.06 inches) +/- 10 %.

Proprietary adapters for threaded base elements should also have a blunted V-shaped knife edge with the same dimensions as given above.

3.1.2.10 Access to elements

Vessels with lid weights exceeding 18 kg (40 lbs) shall have lids hinged or pivoted to the vessel body, and the lids secured with swing-type eye bolts unless special installation conditions require otherwise. Small covers that are not hinged or pivoted may require a handle to assist with lifting and support lugs on the vessel to assist with location while fitting.

Vertical vessels that incorporate a sleeved lift column attached to the cover, operated by a hydraulic jack or cam lever, shall incorporate a safety device so that the cover, once raised, cannot inadvertently drop. Typically, this can be achieved by inserting a pin through the lift column above its guide sleeve.

In order to facilitate maintenance of vertical vessels, and especially if the vessel includes hardware or other items assembled to the element mounting plate, the length to diameter ratio of the main shell should not exceed 1.75:1 except where the vessel nominal diameter exceeds 712 mm (28 inches) or the items can easily be reached by hand i.e. the cover to mounting plate length is less than 500 mm (20 inches).

Sealing of the cover to the vessel end flange or reinforcing ring is preferably done using an O-ring seal rather than a flat gasket.

3.1.2.11 Element supports

The free ends of all elements regardless of mounting assembly, should be supported firmly against vibration in accordance with 3.1.2.11.1 or 3.1.2.11.2.

3.1.2.11.1 50 mm (2 inch) diameter elements

For vessels which include a cover interlock system employing devices to locate on the element ends, a separate spider may not be necessary. However, an intermediate support grid should be provided if the length and weight of wetted elements would cause them to droop, become unseated or otherwise result in the ends becoming misaligned with the end support spider.

When the end support is assembled, there shall be sufficient clearance between the element outer diameter and the intermediate support grid to avoid chafing and allow fuel to pass through without undue restriction. It should also allow sufficient lateral movement without the end support so that when elements are being removed, they can be grasped easily by a gloved hand.

3.1.2.11.2 150 mm (6 inch) diameter elements

One method is to use a spider plate joining the element ends together and stabilising this against the vessel wall. The method of stabilisation may be by bolting the spider to a lug on the vessel wall, this also serving as the electrical bonding point, or by an adjustable arm edged with a rubber sleeve. In the latter case, the spider should be bonded separately and in both cases, the resistance should be less than 10 ohms.

The spider should incorporate a method of accommodating end bolt or tie rod misalignment of up to 12.7 mm (0.5 inch). The preferred method is for the location point in the spider to be comprised of a slotted plate on each side, riveted together, the assembly being free to rotate.

Note: For a 0.5 inch UNC or 12 mm O.D. metric coarse thread, the slot would need to have an overall length of 38 mm (1.5 inches).

3.1.2.12 Clean-out connection

All parts of the vessel shall be accessible for inspection and cleaning. Access may be from the main cover, the inlet and outlet connections for vessels mounted on mobile equipment, or alternatively a specially installed clean-out connection of minimum 125 mm (5 inch) internal diameter. The clean out connection itself shall not constitute a water trap.

Removal of the vessel's inlet or outlet piping is not an acceptable method for monitor vessels in fixed installations.

3.1.2.13 Drain and sample ports

Sample ports shall be provided to permit the taking of influent and effluent fuel samples under flow conditions.

Water/sample drains shall be provided at the low points of the inlet and outlet compartments and to the deck plate if applicable.

Deck plates on vertical vessels should be sloped towards the drain point and shall be completely self draining.

3.1.2.14 Branch and port marking

Inlet and outlet branches, together with all other ports should be clearly labelled to indicate their intended function. Engraving or stamping is not acceptable unless it is deep enough to avoid being obliterated by several coats of paint and is in accordance with any limitations imposed by the design code.

3.1.2.15 Data plate

A stainless steel or non-ferrous data plate shall be securely attached to vessel. This plate shall include as a minimum, the manufacturer's name and location, serial number, model number, rated flow capacity, date of manufacture, number and type of elements, recommended maximum differential pressure, construction code, design pressure, hydrostatic test pressure, API/IP Specification No., operational temperature range and any other pertinent data.

3.1.3 Materials of construction

3.1.3.1 Operational environment

The manufacturer shall ensure that the unit shall not be adversely affected by the operational environment. The purchaser may define this in terms of temperature range[13], atmospheric conditions, salinity etc. If not specified by the purchaser the standard temperature conditions are defined as:

-29°C to +70°C (-20°F to +160°F)

Furthermore, the element media, gaskets and sealing material and internal coatings if any, shall not deteriorate due to exposure to fresh water, salt water or aviation fuels, and shall not promote the growth of fungi.

3.1.3.2 Metallurgy

All metal parts in contact with the fuel shall be free of zinc, cadmium, copper and their alloys. Vessels may be either of stainless steel, aluminium or carbon steel. Carbon steel vessels shall be internally coated with a suitably approved light coloured epoxy coating. Sensing lines shall be stainless steel.

3.1.3.3 Gaskets, seals and coatings

All gaskets, seals and coatings shall be compatible with all aviation fuels and meet relevant industry and/or military specifications.

Note: Cork, rubber-impregnated cork and compounds containing asbestos are not acceptable.

13 Units may need to be designed so as to not be adversely affected by temperatures as low as -50°C for some operating environments.

3.1.3.4 Exterior paints

Prior to shipment, the exterior of a vessel shall be cleaned of all dirt, grease, rust and loose mill scale, and one coat of an approved metal primer applied, unless otherwise specified[14]. All nameplates, gauges, etc. shall be masked prior to painting.

The paint used shall be fuel resistant, suitable for further coating and sufficiently durable to afford protection against corrosion in humid, saline conditions during shipment handling and site installation.

3.1.4 Electrical continuity

All metal items inside the vessel shall be in electrical contact with each other and the vessel itself. The resistance between any two items shall be less than 10 ohms.

In the case of carbon steel vessels which are internally coated, the exterior of the vessel may be used as a contact point for continuity tests. For aluminium vessels and aluminium bushes or check valves installed in a coated steel mounting plate, oxide film may be removed from a contact point before conducting continuity tests.

3.2 STANDARD ACCESSORIES

The following accessories shall be standard on all units and may be fitted by the vessel manufacturer, vehicle constructor or on site at the discretion of the purchaser.

3.2.1 Equipment for measuring differential pressure

Filter element condition and life shall be determined by checking the differential pressure at rated flow. Sensing lines and fittings shall be made from stainless steel. Isolating valves shall be stainless steel in fixed facilities, while for mobile equipment, stainless steel or chromium plated brass may be used providing compression ferrules, if used, are of suitable hardness.

The possible pressure measuring alternatives are:

(a) A differential gauge giving a direct reading is recommended. Both electronic pressure transducers and piston-type devices are available. The gauge shall be protected with suitable isolating valves and for piston-type devices provided with a means for testing free movement of the piston.

(b) A single pressure gauge with a 3-way valve to enable pressure upstream and downstream of the elements to be measured in turn and the difference determined. This type of gauge shall have pulsation dampeners, a range compatible with the system in which it is used, 75 mm to 125 mm diameter face and maximum 0.1 bar sub-division.

Note: This eliminates any fixed bias or error in the gauge. Two separate gauges can give a false result.

3.2.2 Air eliminator

The filter monitor shall be fitted with a means to automatically vent trapped air from the highest point of the vessel.

3.2.3 Pressure relief valve

Provision shall be made for the fitting of a pressure relief valve to ensure that the design working pressure of the vessel is never exceeded. Pressure relief provisions should be set in accordance with ASME VIII, or other recognised pressure vessel code agreed by the purchaser.

3.2.4 Sampling connections

Sampling connections shall be provided at the inlet and outlet of the vessel to enable membrane tests or other fuel quality checks to be carried out.

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14 Stainless steel and aluminium vessels need not be prime painted before shipment unless specified by the purchaser.

3.3 OPTIONAL ACCESSORIES

3.3.1 Quick disconnect dry-break couplings

These may be used for connecting a master gauge to check the accuracy of other gauges fitted.

3.3.2 Non-return valve for the air eliminator

If associated piping and tank heights could allow the vessel to self drain by gravity, allowing air to enter via the air eliminator, a soft-seated non-return (check) valve should be installed.

3.3.3 Work platforms

For tall vertical vessels in fixed installations, work platforms may be needed to ensure that elements can be changed safely. They may be attached to the vessel shell using brackets rather than being welded directly to it.

3.3.4 Flow limiter

A flow limiting valve may be required if, due to system design, there is a possibility of the rated capacity of the vessel being exceeded.

3.3.5 Safety features

Any fail-safe features shall be capable of withstanding the full differential test pressure of 12 bar for ten minutes with a leak rate of less than 0.3 % of full rated flow. In this context, the safety feature is intended to prevent unfiltered fuel from passing downstream if an element is missing or fitted incorrectly.

3.3.6 Cover interlock

This device is an integral part of the vessel. It is designed to ensure that when installing a set of new elements, if one is omitted or not located in a mounting hole, it will not be possible to close the cover.

4

SUPPLEMENTARY INFORMATION

4.1 TEST MATERIALS AND FACILITIES

4.1.1 Test apparatus

Qualification performance tests shall be carried out using test facilities described and illustrated in this section. Test vessels shall be capable of withstanding shock-pressures expected during the start/stop operation. A test rig suitable for the performance of tests to this specification is shown in Figure 1.

Means shall be provided for removing all significant dirt and free water from the test fuel, for measuring the flow rate through the test filter monitor, and for measuring the influent temperature and pressure differential across the unit. Means shall also be provided for sampling the influent and effluent streams from the test unit, and for the introduction of test contaminants and additives.

All critical equipment used for measuring relevant specified parameters shall be calibrated within the ranges and to the accuracy required by this publication. Calibration data should be confirmed prior to conducting a qualification test.

For the dispersed water absorption tests the water is injected at a point as close as possible to the inlet side of the main pump which will produce the necessary fine water droplets. Test dusts shall be injected at a point upstream of the test vessel as a slurry in test fuel. The slurry shall be prepared using a recirculation system as shown in Figure 2.

4.1.1.1 Sampling probes

Upstream facing, probe-type sampling devices shall be provided within 10 pipe diameters of the outlet or inlet of the test unit.

Such probes shall be installed in the pipe with five diameters of clear pipe before them to avoid upstream interference with the flow pattern. Sample pipe layout and size shall be designed to preclude particle settlement in areas upstream of the sampling point.

4.1.1.2 Fuel tanks

Test fuel volume shall be sufficient to accommodate a single element, single pass test. At least two fuel storage tanks are therefore required. Fuel tanks shall be calibrated and calibration charts available. Where dip sticks are used, they shall also have calibration documentation.

4.1.1.3 Pumping unit

The test system pump shall be of the centrifugal type and have a minimum shaft speed of 2950 RPM and a minimum pump stall pressure of 5 bar. It shall be capable of pumping clean, dry fuel at 115 % of the full rated flow of the equipment on test without an excessive temperature rise.

Note: For structural testing of elements a pressure of 12 bar is required. If this cannot be achieved by the use of the above test system pump then a separate system will be required. In the alternative system to reach 12 bar, any pump capable of achieving the required pressure is acceptable.

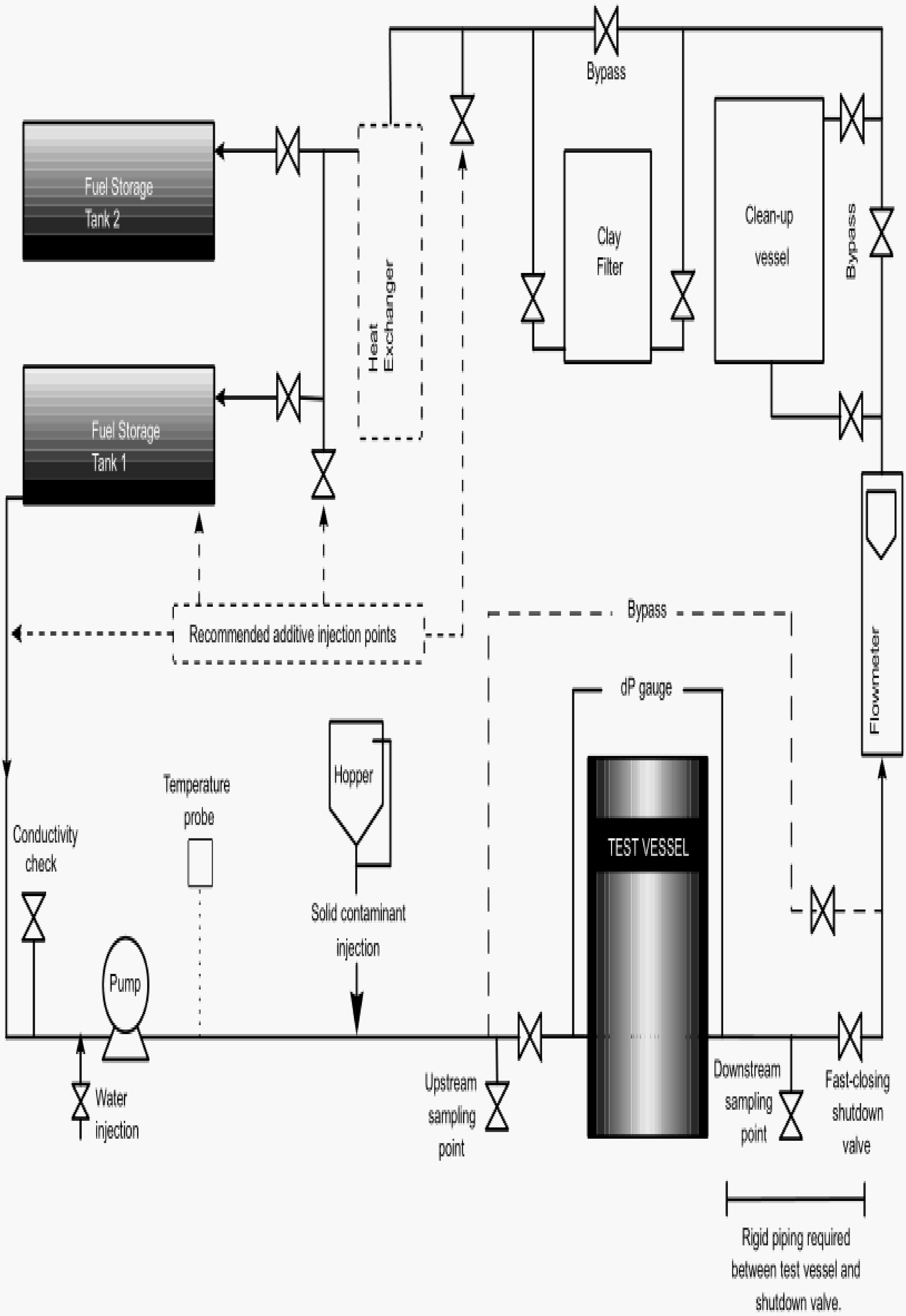
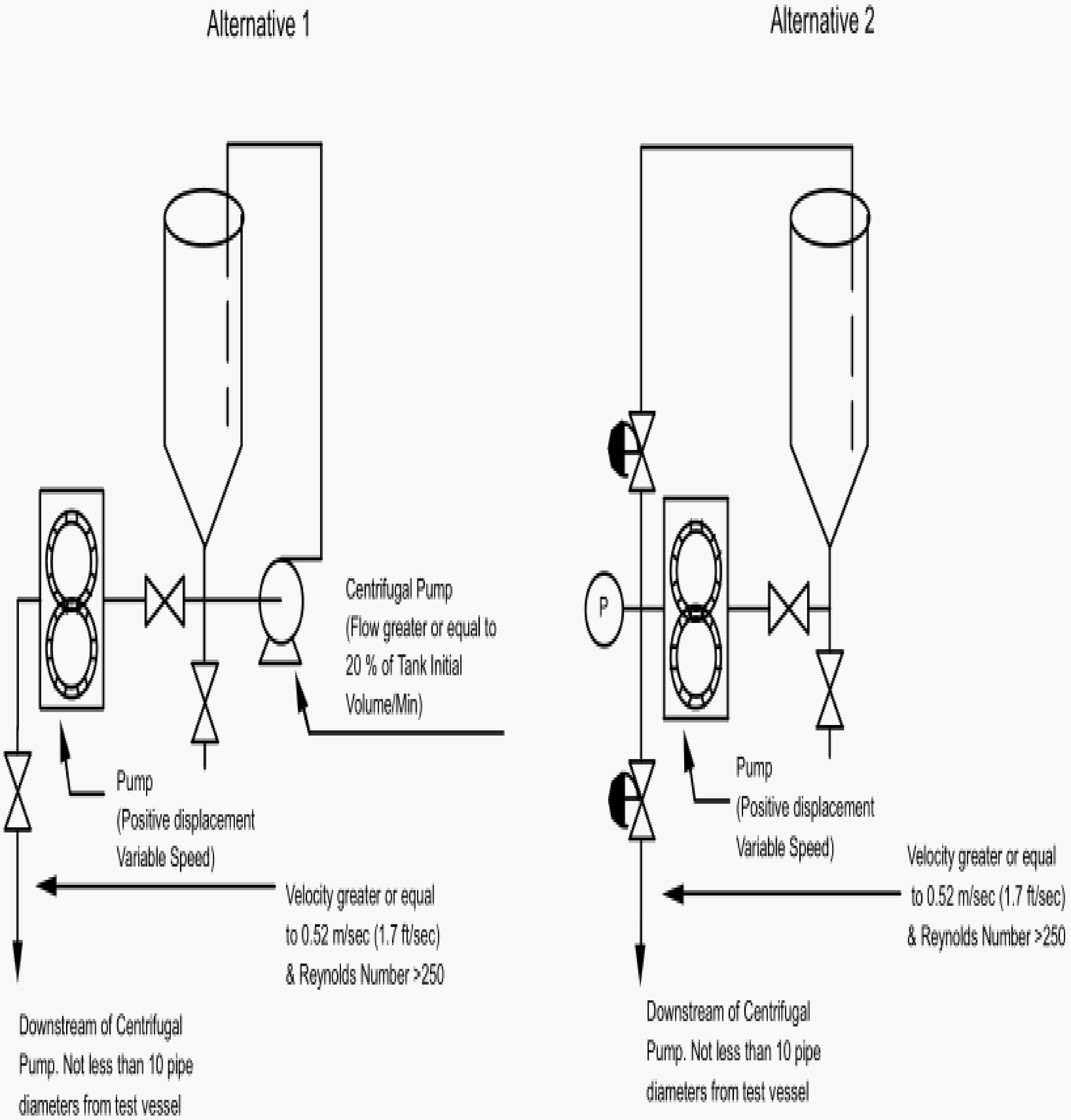


Figure 1 – Test facility



Notes:

1. Slurry volume concentration determined by flow rate (maximum 15 g/l).
2. Pump is variable positive displacement.
3. For Alternative 1, centrifugal pump sized to maintain slurry concentration constant in vessel (~20 % of initial tank volume/minute).
4. For Alternative 2, displacement pump sized to recirculation rate at ~ 20 % of initial tank volume/min at required injection rate.
5. For Alternative 2, injection rate must be measured by flow meter and/or level change.

Figure 2 – Solids addition system

4.1.2 Test fuel

The jet fuel used in all tests shall conform to ASTM Specification D1655 or Def Stan 91-91 for Aviation Turbine Fuels Jet A or Jet A-1 or shall be in accordance with the current issue of the AFQRJOS Joint Fuelling System Checklist Specification for Jet A-1.

4.1.2.1 Test fuel temperature
The test fuel shall have a minimum temperature of 5 °C and a maximum temperature of 30 °C during testing. Test fuel temperature shall be maintained within ± 3 °C of the starting temperature of any individual test run.

4.1.3 Test contaminants

The following contaminants shall be used:

(a) Elementis Red Iron Oxide R-9998[15] or its exact equivalent.

(b) A1 Ultrafine Test Dust ISO 12103-1[16] or its exact equivalent.
Note: The test dusts shall be oven dried at 100 °C for 3 hours within 24 hours of use and placed in sealed containers. All obvious agglomerated lumps shall be removed before use.

(c) Locally supplied fresh water.
Note: It is the responsibility of users of this specification to be aware of the quality of the water in terms of solids content (SC), surface tension (ST) and pH. Recommended limits for these properties are SC <1.0 mg/l, ST >65mN/m and pH 6-8.

The solids test mixture shall consist of 10 % by weight of R 9998 and 90 % by weight A1 Ultrafine.

Note: The test dusts contain fine particulate. The A1 Ultrafine test dust contains silica. The precautions prescribed by appropriate health regulations and standards must be applied when handling these materials.

Contaminants shall be added continuously and evenly, within ± 10 % of the required rate and the average addition rate over the whole test period shall be within ± 3 % of the required rate. Test dust shall be injected at a point upstream of the test vessel as a slurry in test fuel.

4.1.4 Additive package

The following additives shall be introduced to the test fuel at the time and in the quantity and manner specified in the test procedure:

Additive I	Stadis 450 manufactured by Du Pont conforming to the latest product specification[17].
Additive II	Hitec-580 conforming to MIL-I-25017 latest revision[18].
Additive III	Petronate L manufactured by Witco Chemical Company[19].

4.2 SIMILARITY CONDITIONS FOR ELEMENTS OF LENGTHS OTHER THAN THAT OF THE QUALIFIED ELEMENT

The nominal flow rates in section 1.6.3.4 are specified in relation to the overall or nominal length of the element. They yield flow rates for the element which simplify the calculation of the overall flow rate of a vessel. Whilst the qualification may be carried out on a particular length of element, other lengths of the same type of element may be required for various operational reasons. This section describes a procedure for calculating acceptable equivalence (similarity) for elements of lengths other than that of the qualified element.

For 50 mm (2 inch) diameter elements, the effective rated flow shall be 2.5 litres/sec/m (1.0 gpm/inch). This effective flow rate has been calculated from the ratio of effective to nominal lengths of currently available 30 inch nominal length elements and is equivalent to the nominal rate specified in section 1.6.3.2.

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15 R9998 can be obtained from Elementis Inc., 2001 Lynch Avenue, East St. Louis, IL 62205, USA. www.elementispigments.com.
16 ISO 12103-1 can be obtained from Powder Technology Inc., P.O. Box 1464, Burnsville, MN 55337, USA. www.powdertech.thomasregister.com.
17 Stadis 450 may be obtained from Associated Octel. Offices worldwide. www.octel-corp.com.
18 Hitec 580 may be obtained from Ethyl Corporation, P. O. Box 2189, Richmond, VA 23218, USA. www.ethyl.com.
19 Witco can be contacted at www.witco.com

Because the type and size of end-cap adopted by manufacturers is used universally on all lengths of element, in shorter element lengths the ratio of effective length to nominal length decreases. Thus it is necessary to specify permissible maximum increases in effective flow rates for these elements to ensure that the media do not become excessively over-rated.

This is done by applying the following equation:

$$K = \frac{Q_L - S_L}{S_L}$$

where:

K = the maximum acceptable percentage increase in the effective flow rate of the element compared with the qualified version

Q_L = the nominal length of the qualified element

S_L = the nominal length of the element for which similarity is being sought

EXAMPLE: The normal qualification length of a 50 mm (2 inch) diameter element is 30 inch (Q_L = 30). If similarity is being sought for a 10 inch element (S_L = 10), then K = 10. Thus the increase in effective rated flow for a 10 inch element can be no greater than 20 % of the effective rated flow of a 30 inch element.

Because the contribution of the end caps in 150 mm (6 inch) diameter elements does not alter the effective/nominal length ratios to any great extent, calculating similarity for these elements is much simpler. Thus for 150 mm (6 inch) diameter elements, up to three times the length of the test element will qualify by similarity, provided that the longest element can meet the mechanical integrity tests, Runs 4 and 7 (see 2.2.5.4 and 2.2.5.7) and the water slug test, Run 3 (see 2.2.5.3).

For elements not meeting the above similarity conditions, a separate qualification will be required.

4.3 LABORATORY ANALYSIS OF MEDIA MIGRATION SAMPLES

The contaminant is extracted in the normal way and weighed, in accordance with IP 216 (ASTM D 2276). It is preferable, however, to use gridded membranes as the grid markings facilitate the subsequent fibre counts.

After weighing place the test membrane under a low power binocular microscope (overall magnification about X20) and examine the whole membrane surface for fibres. For the purpose of this procedure, a fibre is defined as any particle having a length equal to or greater than ten times its width, and having a length of 100 microns or more.

The number of fibres per litre of sample shall be reported.

4.4 RUN 11, COMPATIBILITY TESTS

4.4.1 Table 2 Schedule of tests

Test Sample	Test Fluid[1]	Hours on Test	Tests Required on Each Solution[2]
1	Jet A or Jet A-1	336	A, B, C, D, E
2	Jet A or Jet A-1 with 35 ppmv of Hitec 580 and 5 ppmv of Stadis 450	336	B, C, D, E
3	50 % Fuel System Icing Inhibitor (FSII) (Di-EGME) in water	336	D
4	30 % vol. toluene/70 % vol. iso-octane	336	B, D, E

Note 1:
Jet A or Jet A-1 used in Tests 1 and 2 shall be as specified in section 4.1.2 and shall be from the same refinery batch.
Jet A or Jet A-1 used in Test 1 shall be clay treated until the conductivity is below 10 pS/m.
Jet A or Jet A-1 used in Test 2 shall be clay treated until the conductivity is below 10 pS/m prior to additive addition.
The additives used in Test 2 shall be as specified in section 4.1.4.
In Test 3 Di-EGME is diethylene glycol monomethyl ether.

Note 2:
Immediately prior to the start of Tests 1 and 2 a representative sample of each solution shall be tested for A, B, C and E shown below.
Immediately prior to the start of Test 4 a representative sample of each solution shall be tested for B shown below.

Test A = MSEP (per ASTM D 3948) or WASP (per IP 452);
Test B = Existent gum (per ASTM D 381);
Test C = Water reaction (per ASTM D 1094) Interface rating only;
Test D = Detailed visual inspection of all component parts;
Test E = Colour (per ASTM D 156).

4.4.2 Reporting The following is a suggested reporting scheme for this activity:

Table 3 Run 11 — Results of compatibility tests suggested reporting scheme

A - MSEP (ASTM D 3948) or WASP (IP 452)				
Test	**Test Fluid**	**Test Hours**		**Comments**
		0	336	
1	Jet A or Jet A-1			
	Reference Sample			
	Post element soak	NA		

B - Existent gum (ASTM D 381)				
Test	**Test Fluid**	**Test Hours**		**Comments**
		0	336	
1	Jet A or Jet A-1			
	Reference Sample			
	Post element soak	NA		
	Difference	NA		
2	Jet A or Jet A-1 with 35 ppm of Hitec 580 and 5 ppm of Stadis 450			
	Reference Sample			
	Post element soak	NA		
	Difference	NA		
4	30 % Toluene/ 70 % Iso-Octane			
	Reference Sample			
	Post element soak	NA		
	Difference	NA		

C - Water reaction test (ASTM D 1094) - Interface rating				
Test	**Test Fluid**	**Test Hours**		**Comments**
		0	336	
1	Jet A or Jet A-1			
	Reference Sample			
	Post element soak	NA		
2	Jet A or Jet A-1 with 35 ppm of Hitec 580 and 5 ppm of Stadis 450			
	Reference Sample			
	Post element soak	NA		

Table 3 Run 11 – Results of compatibility tests suggested reporting scheme continued.

D - Detailed visual inspection of elements after soak		
Test	**Test Fluid**	**Comments**
1	Jet A or Jet A-1	
2	Jet A or Jet A-1 with 35 ppm of Hitec 580 and 5 ppm of Stadis 450	
3	50 % fuel system icing inhibitor (Di-EGME)	
4	30 % Toluene/ 70 % Iso-Octane	

E - Colour (ASTM D 156)				
Test	**Test Fluid**	**Test Hours**		**Comments**
		0	336	
1	Jet A or Jet A-1			
	Reference Sample			
	Post element soak	NA		
	Difference	NA		
2	Jet A or Jet A-1 with 35 ppm of Hitec 580 and 5 ppm of Stadis 450			
	Reference Sample			
	Post element soak	NA		
	Difference	NA		
4	30 % Toluene/ 70 % Iso-Octane			
	Reference Sample			
	Post element soak	NA		
	Difference	NA		

4.5 Table 4 Test sampling schedule and procedure

TEST	RUN	WHEN SAMPLES ARE TAKEN	SAMPLE SIZE	PURPOSE	NO. OF SAMPLES	SAMPLING POINT	SAMPLE TYPE
Media migration 1	1	At start	As required	MSEP/WASP	1	Test unit effluent	Special container
		At start	As required	Conductivity	1	"	Bottle
		At start	5 litre	Media migration	1	"	In-line sampler
		30 mins	5 litre	Media migration	1	"	In-line sampler
		End of test	As required	MSEP/WASP	1	"	Special container
		End of test	As required	Conductivity	1	"	Bottle
Water test, 50 ppmv At full rated flow	2	At start	As required	MSEP/WASP	1	"	Special container
		At start	As required	Conductivity	1	"	Bottle
		At 2, 3 mins (stop/start) then every 10 mins and after 1.0 bar stop/start cycle	As required	Free water content	Varies	"	Aqua-Glo
Water slug test (full flow)	3	Continuous over 5 min period	-	Leak-by volume	5	"	Graduated container
Water slug test (10 % flow)	5	Continuous over 5 min period	-	Leak-by volume	5	"	Graduated container
Solids test	6	At start	As required	MSEP/WASP	1	"	Special container
		At start	As required	Conductivity	1	"	Bottle
		5 (stop/start), 15 mins and then every 10 mins	5 l	Solids content	Varies	"	In-line sampler
Freeze/Thaw test	8	As per Runs 2 and 3					
Full water immersion test	9	Continuous over 5 mins	-	Fuel appearance	5	"	Graduated container

Table 4 Test sampling schedule and procedure continued.

TEST	RUN	WHEN SAMPLES ARE TAKEN	SAMPLE SIZE	PURPOSE	NO. OF SAMPLES	SAMPLING POINT	SAMPLE TYPE
Partial water immersion test	10	At start and after 5 mins	5 l	Media migration	2	Test unit effluent	In-line sampler
		At start and after 5 mins	As required	Free water content	2	"	Aqua-Glo
Low flow water test	12	Hourly, and every 2 hours	As required	Free water content Media migration	Varies	"	Aqua-Glo IP 216
Full-scale vessel water test	13	As for Run 2					
Full-scale water slug test	14	As for Run 3					

4.6 CONVERSION OF FILTER-SEPARATOR AND MICROFILTER VESSELS

A vessel built as a filter-separator or microfilter can in most cases be converted for use with filter monitor elements. Guidance on the conversion process applicable to the majority of vessel types is given in this section.

4.6.1 General

In most cases the design differential pressure rating of the element mounting plate or manifold will be lower than the 1500 kPa requirement specified in section 3.1.2.3. Additional fittings will be required to prevent surge pressure damaging the mounting plate or manifold and creating the risk of bypassing. Typically, this will comprise a pneumatic or electrical switch triggered by a differential pressure of 200 kPa and linked to stop fuel flow (e.g. close a valve or stop a pump).

The switch should be a 'lock-off' type i.e. once it has been activated, it should stay in that position. The reset mechanism should be lockable or accessible only with the use of tools. The arrangement should also include isolating and drain valves to enable simulation of a high differential pressure for routine test purposes.

4.6.2 50 mm (2 inch) and 150 mm (6 inch) conversions

For 50 mm (2 inch) diameter elements it is possible to use a manifold designed to accommodate a cluster of five elements which fits onto the original mounting for an 89 mm (3.5 inch) inside diameter open-ended separator element.

This arrangement, using as many manifolds as necessary for the required flowrate, together with blanking caps, can generally be used in side opening filter separators with an end opposed coalescer/separator design and also in side by side designs where there are sufficient separator mounting ports.

With end opening horizontal filter-separators having end opposed elements and a sandwich plate between the cover and vessel shell, it is preferable to install monitor elements on the plate at the rear of the vessel. The sandwich plate can then be removed completely and the cover hinges altered to suit.

In the case of 150 mm (6 inch) diameter elements, there is a choice of using out-to-in or in-to-out models, out-to-in being the preferred option. Those selected will depend on the required flow direction. Where the flow is from out-to-in, a manifold holding five x 50 mm elements may also be used (see above).

Figure 3 shows the simplest form of conversion where 150 mm diameter in-to-out flow monitor elements have directly replaced the 150 mm diameter filter coalescers which also have an in-to-out flow format.

To enable the preferred out-to-in configuration, the monitors shall be mounted at the outlet of the vessel either directly on the separator mounting stools or on a special manifold mounted on the separator stools with an increased number of element positions - either for 50 mm (2 inch) diameter elements or 150 mm (6 inch) out-to-in flow elements (see Figures 4 and 5). However, most end opening filter-separators with a side by side coalescer/separator arrangement, have a limited number of outlet ports, or utilise a manifold with perhaps one to three separator elements. In this case, to accommodate the number and/or length of monitors to achieve the desired flow usually requires mounting 150 mm diameter elements with out-to-in flow in place of the coalescers and reversing the flow through the vessel.

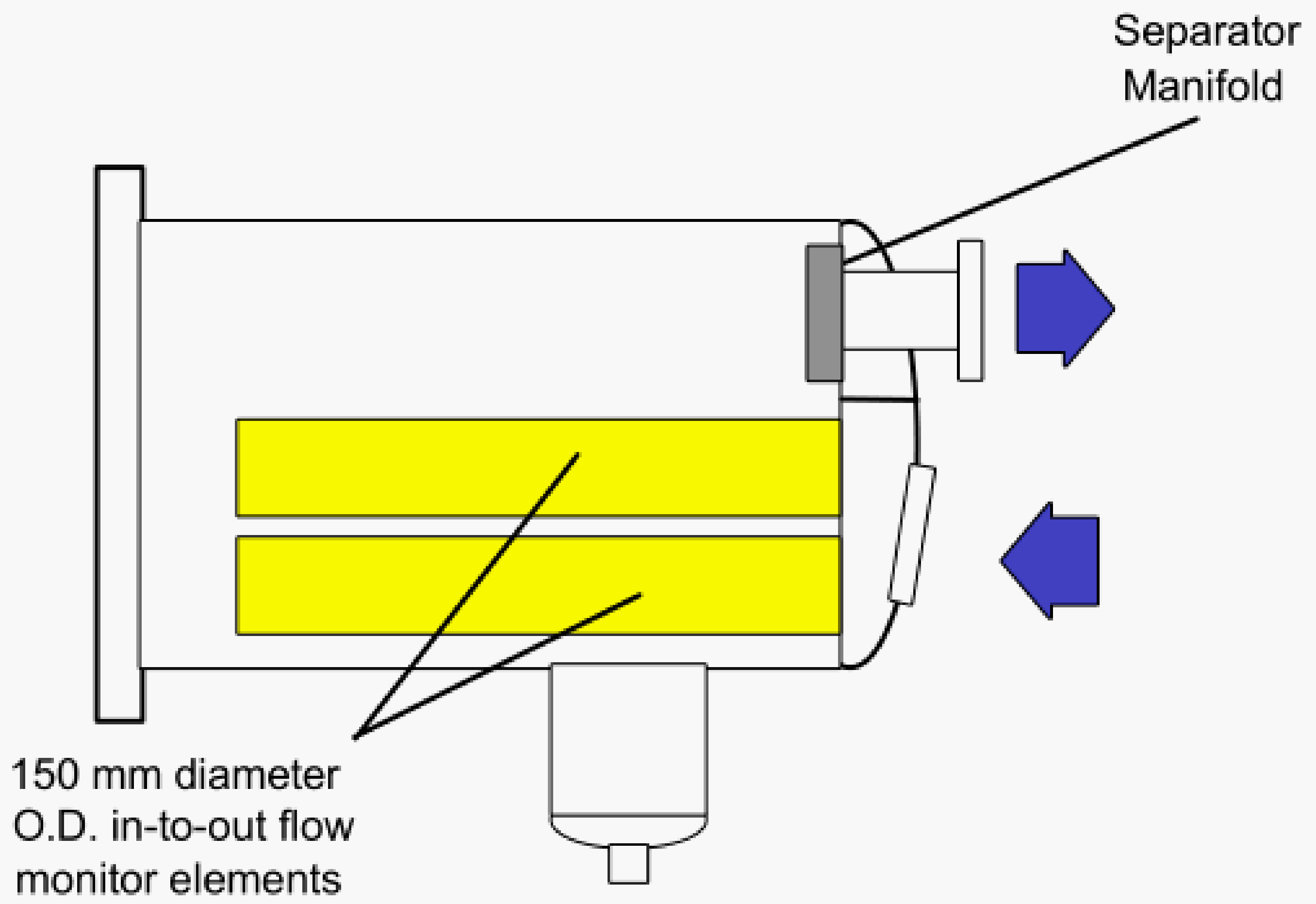

Figure 3 – Simple vessel conversion in which 150 mm diameter filter-coalescer elements are directly replaced by monitor elements with equivalent flow formats

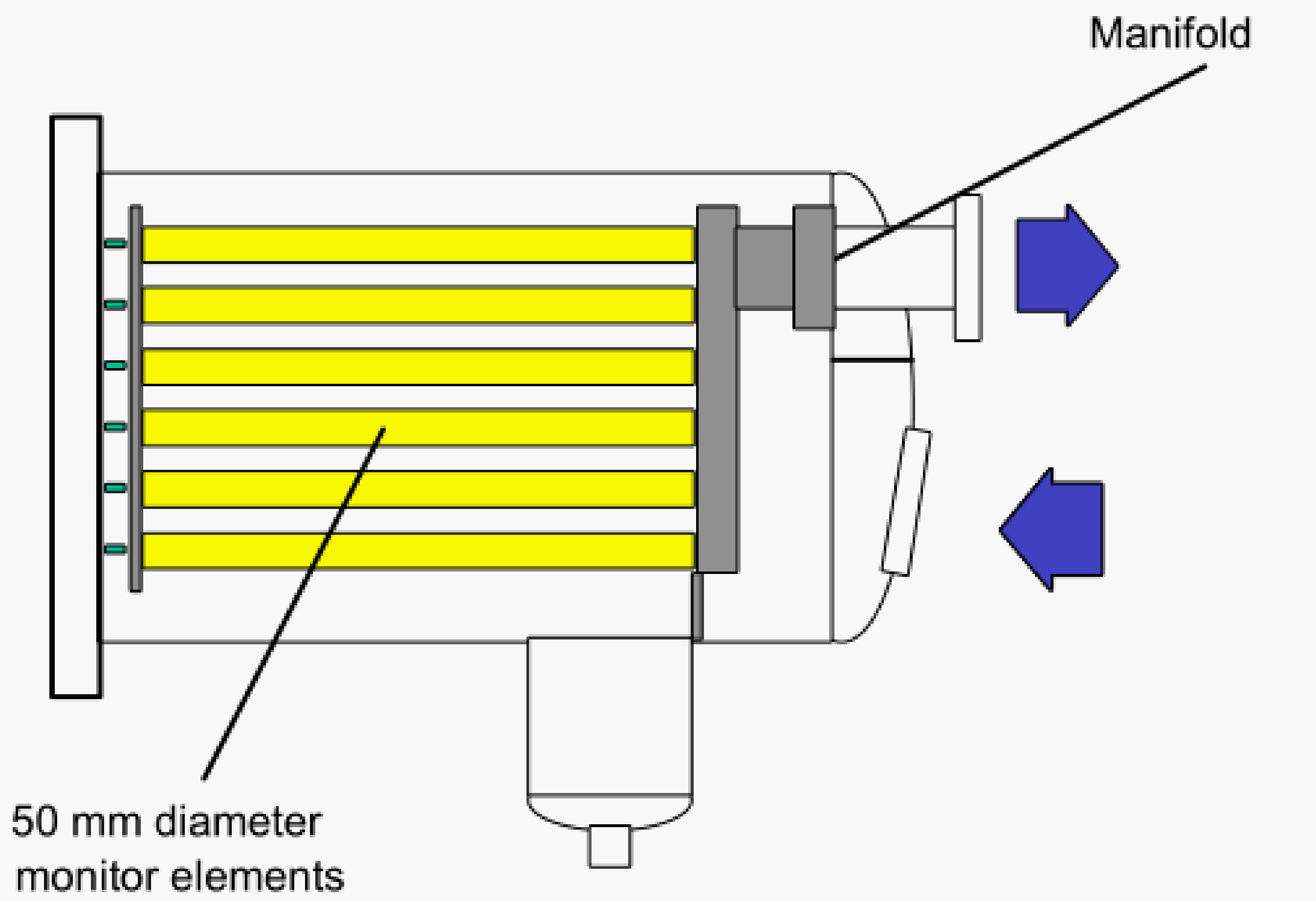

Figure 4 – Separator stool manifold conversion for 50 mm diameter monitor elements

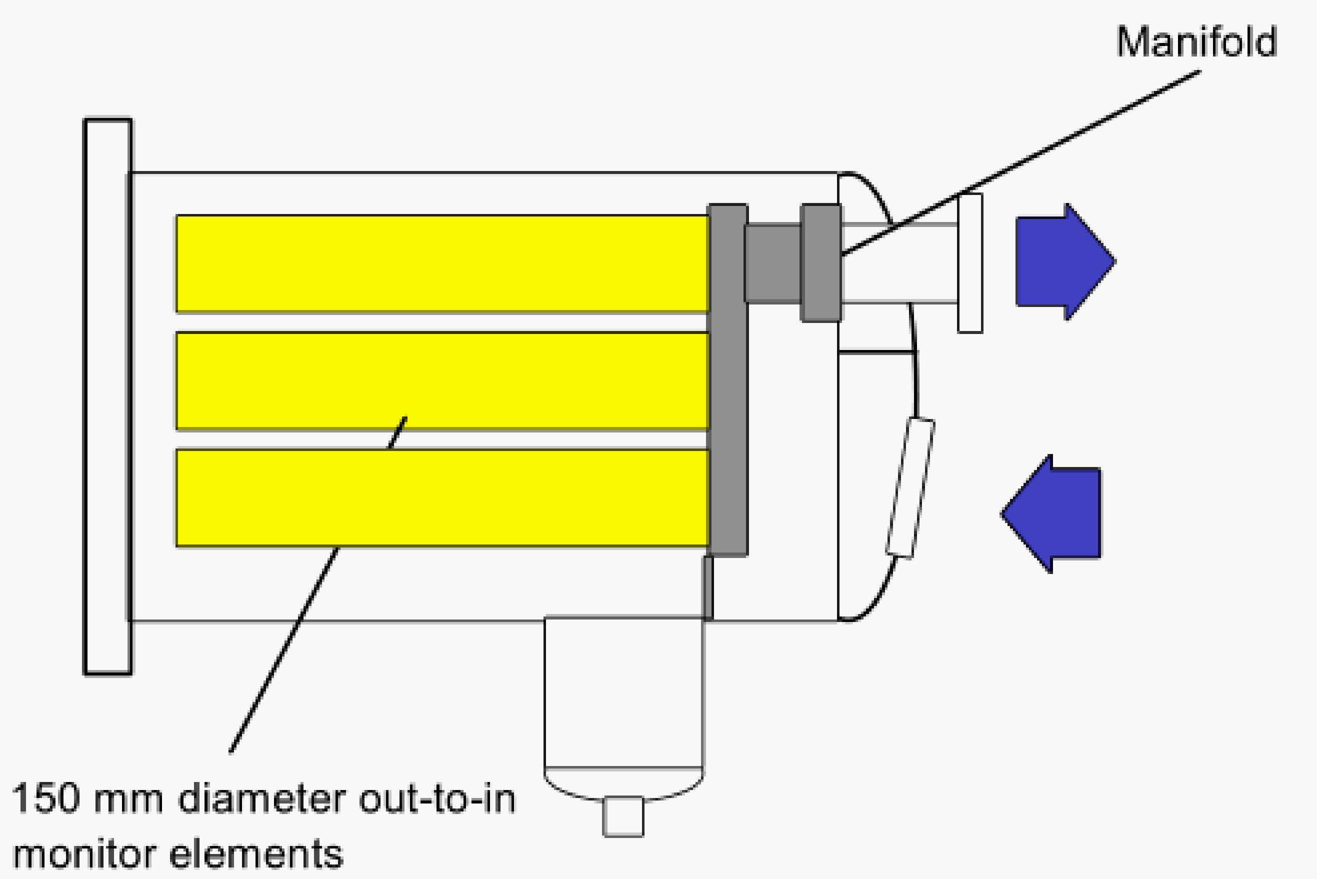

Figure 5 – Separator stool manifold conversion for 150 mm diameter out-to-in monitor elements

Vessels with a large basket type separator element can also be modified with a new manifold installed on the outlet position (see Figures 6 and 7).

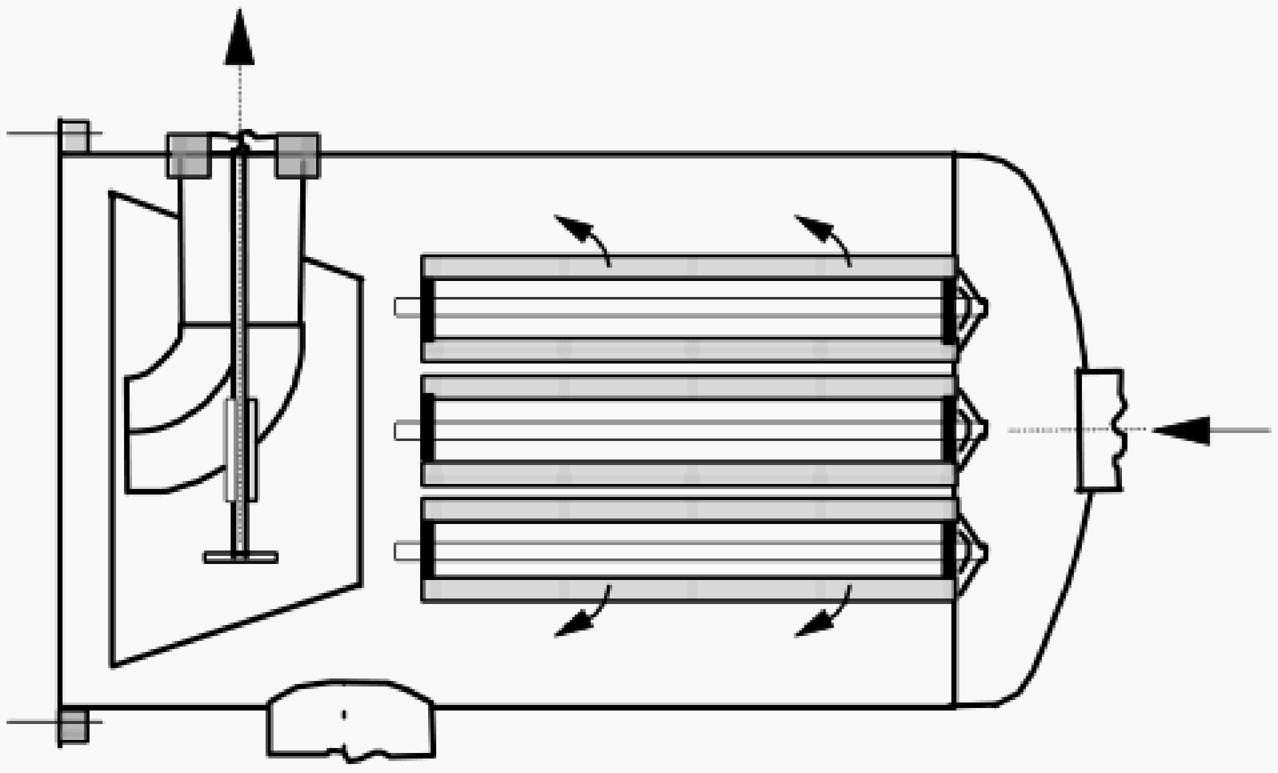

Figure 6 – Filter water separator vessel with large basket-type separator before conversion

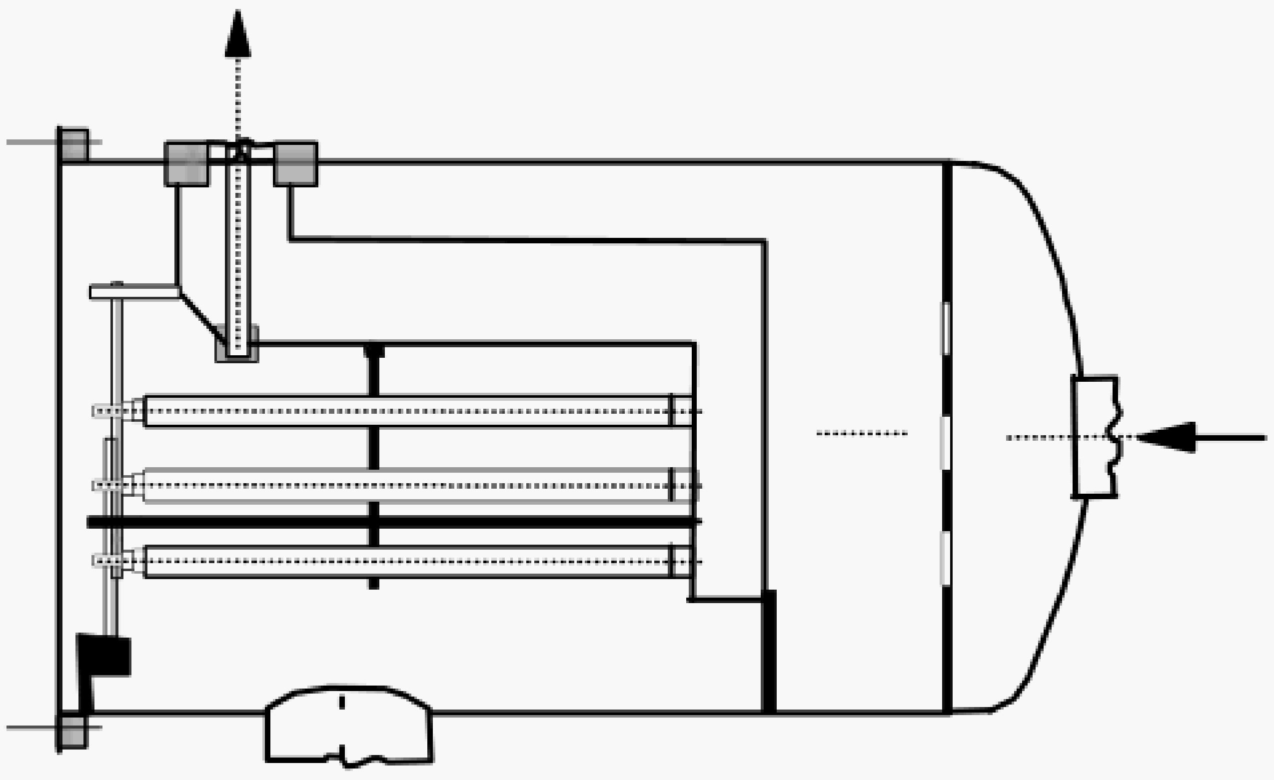

Figure 7 – Vessel in Figure 6 showing outlet manifold conversion for 50 mm diameter monitor elements

4.7 UNIT CONVERSION FACTORS

1 US gallon	3.785 litres
1 litre	0.264 US gallon
1 Imperial gallon	4.546 litres
1 litre	0.220 Imperial gallon
1 kg	2.205 lbs.
1 lb	0.454 kg.
1 bar	14.50 psi
1 bar	100 kPa
1 psi	0.069 bar
1 psi	6.895 kPa
1 dyne/cm	1 mN/m
1 cu	1 pS/m

T °F = 1.8 x T°C + 32