SPECIFICATIONS AND QUALIFICATION PROCEDURES FOR AVIATION FUEL MICROFILTERS

API/IP SPECIFICATION 1590

Second edition
April 2002

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FOREWORD

This is the 2nd edition of this specification. The 1st edition was published by The Institute of Petroleum in 1999. This edition is jointly published by The American Petroleum Institute (API) and The Institute of Petroleum (IP) and has been suitably coded as specification 1590.

This edition of the specification was developed to align API and IP perspectives and clarify certain testing requirements. The test fuel chemistry is changed in this edition to provide alignment with a revision of API/IP 1581 *Specification and qualification procedures for aviation jet fuel filter/separators*, but no changes in element performance requirements between this and the 1st edition of the specification are intended. Equipment qualified to the 1st edition of this specification remains qualified to this edition subject to purchaser's agreement.

This publication describes specifications and qualification test procedures for microfilter elements of the disposable cartridge type and, separately, the manufacturing requirements for new vessels for use in aviation jet fuel-handling systems. It relates only to elements nominally rated within the range 1,0-5,0 µm. This specification provides test conditions and minimum flow rates for microfilter elements having an outside diameter of 150 mm (6 in.). Microfilter elements of other diameters may fall within the scope of this specification when manufacturer and purchaser agree to minimum flow rates and certain test conditions. These specifications are for the convenience of purchasers in ordering, and manufacturers in fabricating, microfilter vessels and elements. They are not in any way intended to prohibit either the purchase or manufacture of microfilter elements meeting other requirements.

Once an element model has been qualified, any change in design or materials voids the qualification of that model. It may not be necessary to conduct all of the performance tests in this specification to re-qualify a modified model depending upon the details of the changes.

The vessel requirements included in this specification refer to new, purpose built microfilter vessels. This specification does not discourage the use of existing vessels, which continue to meet purchasers' needs, regardless of compliance with the mechanical requirements of this specification.

This publication specifies microfilter element performance in terms of single element tests only (no full-scale testing is required). This permits the purchaser maximum flexibility in the application of microfilter elements. Purchasers, however, should be aware that the design and application of full-scale vessels could impact field performance. Users should also be aware that the field performance of microfilters is affected by a number of parameters. For example an additive-containing fuel may subsequently disperse dirt particles collected by a microfilter from an additive-free fuel such that particles are released to the fuel stream.

The American Petroleum Institute and The Institute of Petroleum are not undertaking to meet the duties of employers, manufacturers or suppliers to warn and properly train and equip their employees, and others exposed,

concerning health and safety risks and precautions, nor undertaking their obligations under local and regional laws and regulations.

Nothing contained in any American Petroleum Institute or Institute of Petroleum joint publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

It is hoped and anticipated that this publication will assist both the manufacturers and purchasers of microfilters. Every effort has been made by the American Petroleum Institute and the Institute of Petroleum to assure the accuracy and reliability of the data contained in this publication; however, API and IP make no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any local or regional laws or regulations with which this publication may conflict.

Suggested revisions are invited and should be submitted to the Manager of Standardization, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005, USA or to the Technical Department, Institute of Petroleum, 61 New Cavendish Street, London, W1G 7AR, UK.

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Pall Corporation
Parker Hannifin Corporation
Phillips 66 Company
Shell Aviation Ltd.
Shell Global Solutions
Texaco Ltd.
United Airlines
Velcon Filters
Vic Hughes Associates Ltd.

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GENERAL

(a) This publication covers the recommended minimum performance, mechanical specifications and the recommended testing and qualification procedures for aviation jet fuel microfilters of four nominal ratings[1] within the range 1,0-5,0 µm.

(b) The fuel additives included in this specification are for testing purposes only, and their inclusion does not constitute acceptance or rejection of their use in jet fuels.

(c) This publication uses the Systeme International d'Unites (International System of Units or S.I.). In this system, the decimal point is a comma (,). In writing numbers greater than 3 digits, e.g. thousands, tens of thousands etc. a comma may not be used to demarcate the thousands. Thousands are demarcated by the use of a space. Where necessary, alternative units in common use are given in parentheses. Annex A lists the unit conversion factors used in this specification.

(d) The following publications are cited in this publication; the latest available edition of each referenced publication applies:

API/IP[2]

1581 *Specification and qualification procedures for aviation jet fuel filter/separators*

1583 *Specifications and qualification procedures for aviation fuel filter monitors with absorbent type elements*

ASME[3]

Boiler and pressure vessel code, Section VIII: Rules for construction of boilers and pressure vessels

ASTM[4]

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*

1 "Nominal rating" is a term used to describe an approximation of the (smallest) size particles captured by filters as defined by the performance tests in this publication. Actual capture efficiency of various size particles is a complex function of many parameters so nominal ratings should not be regarded as implying an absolute level of performance.

2 Available from Portland Press Ltd. Commerce Way, Whitehall Industrial Estate, Colchester, CO2 8HP. Tel: +44(0)1206 796 351, email: sales@portlandpress.com; or API Publications, Global Engineering Documents, 15 Inverness Way East, M/S C303B, Englewood, CO80112-5776, USA. Tel: 303 397 7956, Fax: 303 397 2740, www.api.org.

3 American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

4 ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428, USA.

D 1655 *Specification for aviation turbine fuels*
D 2276 *Standard test method for particulate contaminant in aviation fuel by line sampling*
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 4177 *Standard practice for automatic sampling of petroleum and petroleum products*

IP[5]
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)*

JIG[6]
AFQRJOS *Aviation fuel quality requirements for joint operating systems*

US Military[7]
MIL-C-4556 *Coating kit, steel tank interior*

5 Available to purchase from IP Library, 61 New Cavendish Street, London W1G 7AR, UK. Tel: +44(0)20 7467 7100, email: lis@petroleum.co.uk

6 Aviation Fuel Quality Requirements for Jointly Operated Systems (also known as 'Checklist') published by the 'JIG' (Joint Inspection Group) and available from the Joint Inspection Group, c/o 35 Abercorn Place, London, NW8 9DR, UK.

7 US Military, Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120, USA.

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DESCRIPTION

(a) For the purposes of this publication a microfilter is a vessel containing disposable cartridge-type elements that continuously remove, from aviation fuels, dirt of a nominal minimum particle size (element nominal rating in μm). The vessel may have a vertical or horizontal orientation.

(b) This publication specifies test performance requirements for filters of four nominal ratings: 1, 2, 3 and 5 μm.

(c) The nominal rating of the microfilter element shall be clearly quoted by the manufacturer.

3

SPECIFICATIONS

3.1 ELEMENT PERFORMANCE SPECIFICATIONS

In this Section, the minimum performance level of the microfilter element is specified.

Note: Elements are normally qualified for use in vertically orientated vessels but may additionally be qualified for horizontal use by repeating Run 2 of the performance tests (described in Section 5) in the horizontal orientation.

3.1.1 Contaminant removal efficiency

The effluent fuel downstream of the microfilter element shall contain less than 0,15 mg/l particles greater in size than the stated filter rating. Solids transmissions shall be measured by the use of membranes according to the specific element rating as follows:

1,0 µm element	0,8 µm membranes
2,0 µm element	2,0 µm membranes
3,0 µm element	3,0 µm membranes
5,0 µm element	5,0 µm membranes

(For further details on the verification of filter rating see 5.4.2 and Annex D.)

The specified removal efficiency shall be maintained up to a differential pressure of 150 kPa (22 psi).

3.1.2 Media migration

The effluent fuel downstream of the microfilter element shall contain less than 10 fibres per litre. A fibre is defined as any particle with a maximum dimension ten times greater than the minimum dimension and where the maximum dimension is greater than 100 µm.

3.1.3 Flow rate

Elements with a nominal 150 mm (nominal 6 in.) outside diameter shall meet the performance specification at a minimum flow rate of 10 l/sec/m of effective media length (equivalent to 6 l/min/cm or approximately 4 US Gal./min/in). Manufacturers may qualify elements at higher flow rates if they wish.

Note: This flow rate is specified for qualification purposes only. Since element life in a given application is a function of both dirt loading and flow rate, it is recommended that the purchaser consult with the microfilter supplier to establish the optimum flow rate/vessel size for that application. For elements with outside diameters different to that specified above it is not possible to prescribe a minimum qualification flow rate. Manufacturers offering such equipment are advised to qualify at a flow rate maximised for the level of influent dirt indicated in 5.4.

3.1.4 Differential pressure

The manufacturer shall state the average differential pressure across a new element operating at the qualification flow rate with clean, dry fuel in technical literature intended to communicate differential pressure based change out requirements.

3.1.5 Fluid compatibility of elements

The requirements of this publication for compatibility testing (Run 5) are:

(a) The difference in existent gum between the blank run and element run shall be no greater than 8 mg/100 cm^3. If the difference between the initial blank and the blank after the second 336 hour soak period is greater than 8 mg/100 cm^3 then the whole compatibility test run shall be repeated.
(b) The water interface rating shall be no greater than 1b.
(c) Any colour decrease shall be no greater than 4 Saybolt colour units compared with the blank measured after the total soak time period.
(d) There shall be no visual change in the test element.

3.1.6 Structural strength of elements

The filter element shall be capable of withstanding a differential pressure of 500 kPa (72,5 psi) (Element structural test, 5.4.6) without element rupture, collapse or bypassing of seals.

3.1.7 Structural integrity

Filter elements shall meet Run 1-5 performance tests without showing indications of media or structural deterioration as evaluated by the critical examinations specified in Section 5.

3.2 MECHANICAL SPECIFICATION

3.2.1 General

Final acceptance of the microfilter element depends upon its satisfactory functioning during the performance tests described in later sections. New microfilter vessels shall meet the mechanical requirements contained in 3.2.3 and 3.2.4.

Where the purchaser specifies low temperature operability, the manufacturer shall guarantee elements for operation within the temperature range −50 °C to +70 °C (−65 °F to +160 °F).

3.2.2 Design and construction of elements

3.2.2.1 Element sealing
Element-to-mounting-adapter and adapter-to-vessel sealing arrangements shall provide a positive, non-leaking seal against specified design and shock pressures. Methods used will depend on the element design but will include the following:

(a) A flat-base gasket seating against a blunted V-type knife-edge. The height of the V section shall be 1,5 mm (0,06 in.) + 10 % / − 0 % (centre rod installation).
(b) Compressed internal ring joint or O-ring (for axial contact threaded base installation).
(c) Internal O-ring (for radial contact 'push-on' installation).

3.2.2.2 Materials of construction
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. The element media, gaskets and sealing materials shall not deteriorate on exposure to fresh or salt waters. All seals shall be of Viton A, Buna N or equivalent. Under no circumstances is cork or rubber-impregnated cork an acceptable substitute.

3.2.2.3 Element identification
Each individual element shall be permanently marked with the manufacturer's symbol, element model number and/or the nominal rating of the element (in µm) and the date of manufacture. Where possible, the identity of the element should be located so that it can easily be seen when installed in the vessel. Any materials used to mark the element shall not contribute to the contamination of, or be affected by, aviation fuels.

3.2.2.4 Element packaging
Elements shall be packaged for shipment so that mechanical damage and contamination by dirt and water are prevented.

The packaging shall include element installation instructions including, as a minimum, the recommended element fixing torque and, as necessary, information on fasteners for mounting adapters, end cap nut sizes, etc.

3.2.3 Vessel design and construction

3.2.3.1 General
Approval of the mechanical design of a vessel is the responsibility of the purchaser. The purchaser should obtain assurance from the supplier with respect to the performance and design features covered in this Section.

Qualification of vessel performance is not covered by this specification.

3.2.3.2 Design codes

Microfilter 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 equivalent pressure vessel code agreed by the purchaser.

3.2.3.3 Design pressure

Unless otherwise specified by the purchaser the vessel design pressure shall be no less than 1 035 kPa (150 lbf/in^2). The element mounting assembly shall be designed to withstand a differential pressure no less than 750 kPa (110 lbf/in^2) in the direction of normal flow.

Note: For applications where the microfilter may be converted to a filter monitor, the purchaser should specify the design differential pressure of the element mounting assembly. (Compliance with API/IP 1583 is recommended.)

3.2.3.4 Hydrostatic test pressure

Each microfilter vessel body shall be hydrostatically tested to 1 550 kPa (225 lbf/in^2) or 1,5 times the design pressure specified by the purchaser. The upstream side of the mounting assembly shall be hydrostatically tested with all ports sealed to a test pressure of no less than 750 kPa (110 lbf/in^2).

Note: For applications where the microfilter may be converted to a filter monitor, the purchaser should specify the hydrostatic pressure testing requirement (all ports sealed) of the mounting assembly. (Compliance with API/IP 1583 is recommended.)

3.2.3.5 Piping connections

All main fuel piping connections larger than 38 mm (1,5 in.) nominal bore shall have pressure ratings no less than that of the vessel and shall be flanged. Connections of types other than flanged may be substituted 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 a baffle or other means to avoid damage by flow impingement.

3.2.3.6 Ports and connections

Ports shall be female threaded or flanged as specified by the purchaser.

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

Ports having a parallel thread shall have a smooth external face and dimensions suitable for fittings with integral O-ring face seals and those utilising bonded sealing washers (e.g. Dowty and Stat-O-Seal types).

Weld beads on vertically installed half couplings or pipe stubs shall not protrude internally or otherwise contribute to the concentration of contaminants.

3.2.3.7 Vent and pressure relief ports

A port shall be provided at the highest fuel flow point of the vessel for installation of an air eliminator. A pressure relief valve connection port shall also be provided.

3.2.3.8 Pressure measurement ports

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

3.2.3.9 Element spacing

Elements shall not contact other elements or vessel walls. For applications where the microfilter may be converted to a filter monitor, the design layout of elements in the vessel shall, unless otherwise specified, provide a minimum separation of 13 mm (0,5 in.) between elements and between the vessel wall and any element.

3.2.3.10 Element mounting

For vessels designed to accept elements with flat end gaskets (face seal), the mounting surface shall incorporate a blunted V-shaped knife edge 1,5 mm high (0,06 in.) +10 % / −0 %.

Proprietary adapters for threaded base elements shall meet this requirement.

3.2.3.11 Access to elements

Covers weighing more than 18 kg (40 lbs) shall be hinged or pivoted on the vessel body and shall be secured with swing-type eye bolts unless otherwise specified by the purchaser. Small covers, which are not hinged or pivoted, shall incorporate a handle to assist with lifting and support lugs on the vessel to assist with location while fitting unless otherwise specified by the purchaser.

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. One acceptable method is to provide for the insertion of a pin through the lift column above the guide sleeve.

To facilitate maintenance of the vessel, the length

(L, distance from the deck plate to the cover) to internal diameter (D) ratio (L/D) shall not exceed 1,75:1 except where the vessel internal diameter exceeds 710 mm (28 in.) or the length is less than 500 mm (20 in.).

An O-ring is preferred to a flat gasket for sealing the cover to the vessel end flange or reinforcing ring.

3.2.3.12 Element supports

The free ends of all elements, regardless of mounting assembly, should be supported firmly to minimize vibration.

One acceptable method is to use a spider plate to tie the element ends together. The spider plate should be stabilised to the vessel wall by bolting to a lug on the vessel wall or by an adjustable arm edged with a protective fuel-compatible sleeve. A spider shall be bonded to the vessel with a resistance less than 10 ohms.

Note: Designs featuring spiders bolted to the vessel wall normally meet both the requirements for element stabilisation and electrical conductivity (bonding). Some other designs, such as the latter design above, require a separate bonding strap.

The spider shall incorporate a method of accommodating end bolt or tie rod misalignment of +/– 13 mm (0,5 in.). 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 in. UNC or 12 mm O.D. metric coarse thread, the overall length of the slot is 38 mm (1,5 in.).

3.2.3.13 Clean-out connection

All parts of the vessel shall be accessible for inspection and cleaning. Access may be via the cover, the inlet and outlet connections for vessels in mobile service, or a clean-out connection of minimum 125 mm (5 in.) internal diameter. The clean-out connection itself shall not form a water or dirt trap.

Removal of the vessel's inlet or outlet piping is not an acceptable method of meeting this requirement for vessels in fixed (non-mobile) service.

3.2.3.14 Draining

All chambers, including the inlet and outlet branches, must be provided with ports so that fuel and/or any accumulated contamination can be completely removed via low-point drains. To facilitate this, surfaces shall avoid localised low points or stagnant areas. The main chamber containing the elements shall incorporate a definite slope toward a low point. For flat plates the minimum slope shall be 3 degrees. Where manifolds are used in vertical vessels, the lower dished end shall be acceptable without modification. The port size shall be specified by the purchaser but can be typically 22 mm (0,75 in.) reducing to 13 mm (0,5 in.) for small vessels, or increased to 25 mm (1 in.) or larger on large vessels.

Internal weld beads on half couplings or pipe stubs shall not protrude to cause localised trapping of contamination.

The minimum height between any drain/sample port and the ground shall be 600 mm (24 in.). This allows for installation of valves, fittings and extension lines whilst leaving enough clearance for use of a bucket.

3.2.3.15 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.

3.2.3.16 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.

3.2.3.17 Data plates

A permanent stainless steel or nonferrous metal data plate shall be securely attached to the vessel. This plate shall include, as a minimum, the vessel manufacturer's name and address, vessel serial number, unit and model number, date of manufacture, construction code, design pressure, hydrostatic test pressure for the vessel and the element mounting assembly (deck plate), API/IP Specification Number, operational temperature range, and vessel cover gasket material and part number.

A second securely attached removable plastic or metal data plate shall show the name and address of the element manufacturer, the API/IP Specification Number, the model number of elements, the quantity of elements, the rated flow capacity, the recommended maximum differential pressure for the elements, the recommended assembly torque and any other pertinent data.

3.2.4 Materials of vessel construction

3.2.4.1 Operational environment

The manufacturer shall ensure that the unit shall withstand the intended operational environment. The purchaser may define this in terms of temperature range, atmospheric conditions, salinity etc.

If not otherwise specified by the purchaser the intended temperature conditions are defined as:

−29 °C to +70 °C (−20 °F to +160 °F)

Where the purchaser specifies low temperature steel fabrication, the manufacturer shall guarantee new vessels for operation within the temperature range:

−50 °C to +70 °C (−65 °F to +160 °F)

Unless otherwise specified, the element media, gaskets and sealing material and any internal coatings shall not deteriorate due to exposure to fresh water, salt water and/or aviation fuels, and shall not promote microbiological activity.

3.2.4.2 Metallurgy and internal coatings

All metal parts in contact with the fuel shall be free of zinc, cadmium, copper and their alloys. Vessels shall be composed of stainless steel, aluminium or carbon steel. Carbon steel vessels shall be internally coated with an approved light-coloured coating which shall not deteriorate on exposure to fresh or salt waters or aviation fuels nor shall the coating affect fuel quality. Epoxy coatings conforming to MIL-C-4556 or an equivalent specification and other purchaser-approved coatings that have demonstrated equivalent or superior performance (to these epoxy coatings) are suitable.

Sensing lines shall be of stainless steel.

3.2.4.3 Gasket and seals

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

Note: Cork gaskets and formulations containing asbestos are not acceptable.

3.2.4.4 Exterior paints

Prior to shipment, the exterior of the vessel shall be cleaned of all dirt, grease, rust and loose mill scale, and one coat of an approved metal primer shall be applied, unless otherwise specified[8]. All data plates, gauges etc. shall be masked or removed 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.

3.2.4.5 Electrical continuity

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

In the case of carbon steel vessels that are internally coated, the exterior of the vessel may be used as a contact point for continuity tests. For aluminium vessels and aluminium threaded base adapters, the oxide film may be removed from a contact point before conducting continuity tests.

3.2.5 Standard vessel accessories

The accessories detailed in 3.2.5.1 - 3.2.5.4 shall be standard on all units and may be fitted by the vessel manufacturer or on site at the discretion of the purchaser.

3.2.5.1 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.

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 dampers, a range compatible with the system in which it is used, a 75 mm (3 in.) to 125 mm (5 in.) diameter face and maximum 10 kPa (1 psi) sub-division.

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

8 For example see MIL-C-4556.

3.2.5.2 Air eliminator

The vessel shall be fitted with a means for automatically venting trapped air from the highest point of the vessel.

Note: The vessel manufacturer shall request and the purchaser shall provide details of the intended application to ensure that performance of the selected air eliminator meets the requirement.

3.2.5.3 Pressure relief valve

The vessel shall be fitted with a pressure relief valve to avoid over pressurisation due to thermal expansion of the fuel. It should be set in accordance with ASME VIII, or other recognised pressure vessel code agreed by the purchaser, e.g. design working pressure plus 10 %.

3.2.5.4 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. On vertical vessels, the axis of the connections shall be horizontal.

3.2.6 Other vessel accessories

Depending upon the installation, some of the accessories detailed in 3.2.6.1 - 3.2.6.7 may be desirable or required, in addition to those required by 3.2.5.

3.2.6.1 Quick disconnect dry-break couplings

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

3.2.6.2 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 shall be installed.

3.2.6.3 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.

3.2.6.4 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.

3.2.6.5 Sump heaters

In very cold locations it is possible for accumulated water to freeze in sumps and drains. Electrically heated jackets or immersion heaters may be required where such a problem exists.

3.2.6.6 Water-slug valve

This is a valve that is actuated by a sensor or float in the sump of the vessel. Fuel flow is shut down by the valve when actuated as a result of a build-up of water in the sump. The sensor shall be equipped with an external mechanism for function testing.

3.2.6.7 Air-slug relief system

Where excessive amounts of air may be passed into the vessel, sensor or float-type devices may be installed to control the outlet flow rate via, for example, a pilot operated discharge valve, until the liquid level within the vessel returns to normal.

4

QUALIFICATION TEST MATERIALS AND FACILITIES

4.1 TEST MATERIALS AND FACILITIES

Qualification tests shall be carried out using the single-element test facility as described in 4.5.

The single-element test vessel shall be vertical. If required, a qualification for horizontal vessel application may be achieved by repeating Run 2 (5.4.2) in a horizontal vessel.

Data sheets and drawings which describe the general design and media lay-out of the element to be qualified shall be included with the qualification test report.

The nominal length of the element tested in Runs 1 - 5 shall be no less than 250 mm (10 in.). The element tested in the Structural Test (5.4.6) shall be the longest manufactured.

4.2 TEST FUEL

4.2.1 Fuel type

Aviation turbine fuels, Jet A or A-1, conforming to ASTM D 1655 or the current issue of AFQRJOS shall be used. Before each test series, the fuel shall be clay-treated to yield a conductivity (ASTM D 2624, IP 274) of less than 10 pS/m and a free-water content (ASTM D 3240) of less than 5 ppm before the addition of additives.

4.2.2 Fuel volume

The volume of test fuel required shall be sufficient to accommodate the single-element, single-pass test run described in Section 5.

4.3 TEST CONTAMINANTS

4.3.1 Contaminant type

For solids filtration testing the following test dusts shall be used:

— For 1,0 µm rated elements - Red iron oxide (Harcross R9998) test dust[9].
— For 2,0-3,0 µm rated elements - 90:10 A1 Ultrafine silica:R9998 mixed test dust.
— For 5,0 µm rated elements - A1 Ultrafine ISO 12103-1 silica test dust[10].

The test dust(s) shall be oven dried at 100 °C for at least 3 hours within 24 hours of use and placed in sealed containers. All obvious agglomerated lumps shall be removed before use.

For Run 4, the water used shall contain less than 1,0 mg/l of solids, have a surface tension of greater than 65 mN/m at 24 °C and have a pH value between 6 and 8.

9 R9998 can be obtained from Elementis, 2001 Lynch Avenue, East St. Louis, IL 62205.
10 A1 Ultrafine, ISO 12103-1 can be obtained from Powder Technology Inc., P.O. Box 1464, Burnsville, MN 55337.

4.3.2 Contaminant addition

Contaminants shall be added, as a slurry, continuously and evenly, within ± 10 % of the required rate using a system conforming to 4.5. The test slurry shall be comprised of fully additivated test fuel and test dust. The concentration of test dust may be varied as a function of flow rates to meet dirt delivery requirements but shall be no greater than 15 g/l. The slurry shall be recirculated for a minimum of 20 minutes before use.

4.4 ADDITIVE PACKAGE

Stadis 450 and DCI-4A, manufactured by Octel Corporation conforming to the latest product specification shall be introduced to the test fuel in the quantity and manner specified in the test procedures in Section 5.

4.5 TEST FACILITY

4.5.1 Single-element test facility

The single-element test facility used to demonstrate compliance with this publication is depicted in Figure 1. The use of a heat exchanger is optional. The additive injection point is unspecified. The solid contaminant injection point shall be between the pumping unit and the test vessel with a line length to the test vessel (from the contaminant injection point) no less than 10 pipe diameters.

The pumping unit used in the test facility shall be of the centrifugal type with a minimum shaft speed of 2 950 rpm and a minimum stall pressure of 500 kPa (75 psi).

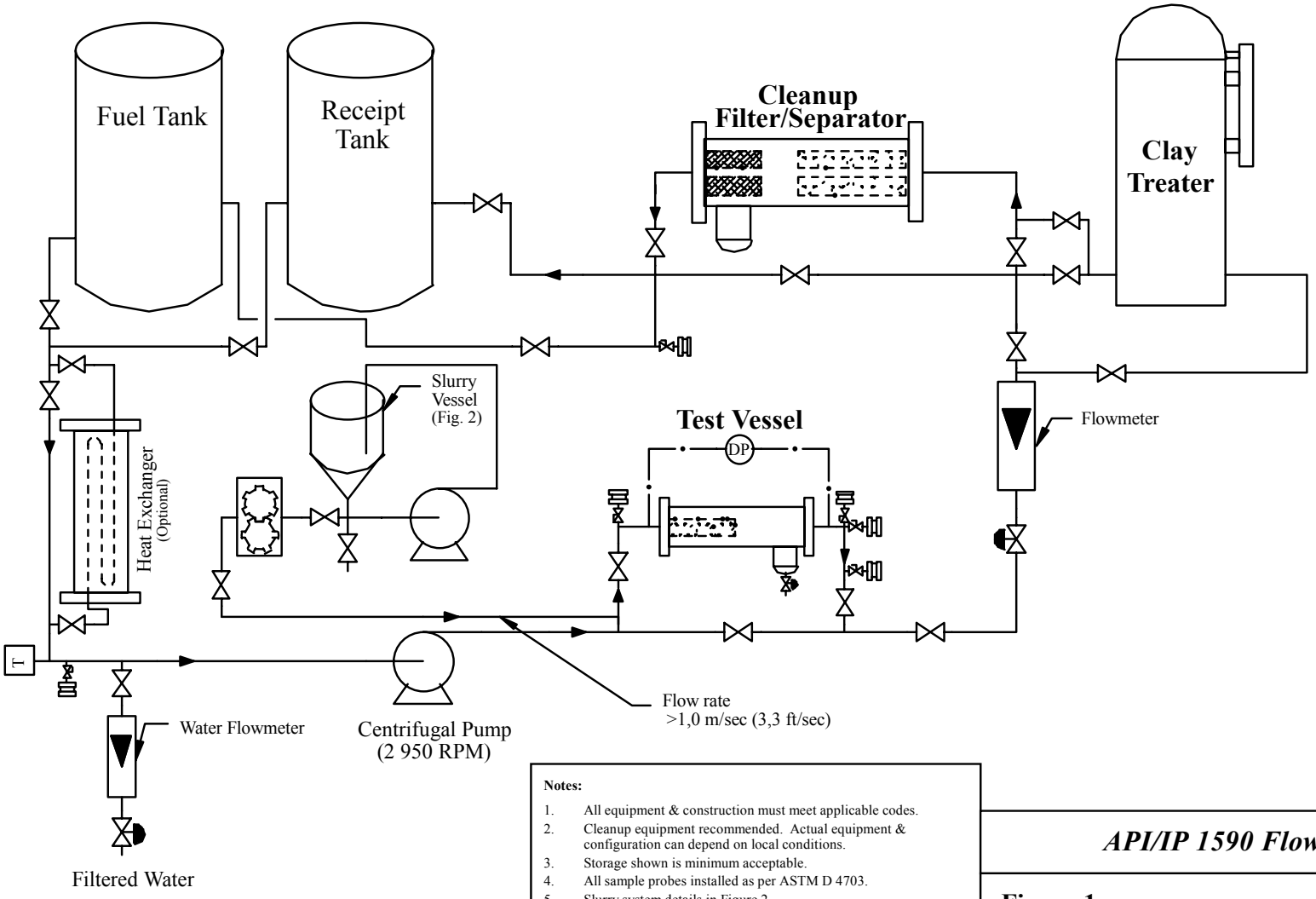
4.5.2 Solid-contaminant injection facility

The solid-contaminant injection facility shall correspond to one of the two alternatives shown in Figure 2. In addition, the facility shall comply with the following:

— The hopper shall have a coned down outlet.
— The hopper volume shall be at least 90 litres.
— The hopper shall be equipped with a valved low point drain to facilitate surplus slurry removal and assay.
— The delivery pump shall be a variable positive displacement type with a stall pressure sufficient to overcome the maximum test rig line pressure arising during qualification performance testing.
— At least 20 % of the volume capacity of the hopper shall be recirculated per minute to maintain the homogeneity of the slurry.

When solid-contaminant injection facility Alternative 2 is used, the upper control valve in the Figure (back pressure control valve) shall be partially closed to generate sufficient back pressure to overcome the test rig line pressure. The lower control valve in the Figure shall be adjusted to control the slurry injection rate (at least 1 l/min). The solids addition rate shall be monitored by using a calibrated level measurement (e.g. sight glass) or a flow meter device.

Slurry injection into the test fuel from the hopper conditioning system shall be done at an even and continuous minimum flow of 1,0 m/s with a minimum Reynolds Number of 2500. A 1/4 turn valve shall be provided on the slurry injection line near the main flow test rig to isolate the slurry system from the main test rig as required (e.g. during stop/start cycles or when idle).



Notes:

1. All equipment & construction must meet applicable codes.
2. Cleanup equipment recommended. Actual equipment & configuration can depend on local conditions.
3. Storage shown is minimum acceptable.
4. All sample probes installed as per ASTM D 4703.
5. Slurry system details in Figure 2.
6. Provision must be made to verify calibration of:
   - Flowmeters
   - Differential pressure gauges
   - Slurry flow rate
   - RPM of centrifugal pump

API/IP 1590 Flowsheets

Figure 1 — Single Element Test Facility

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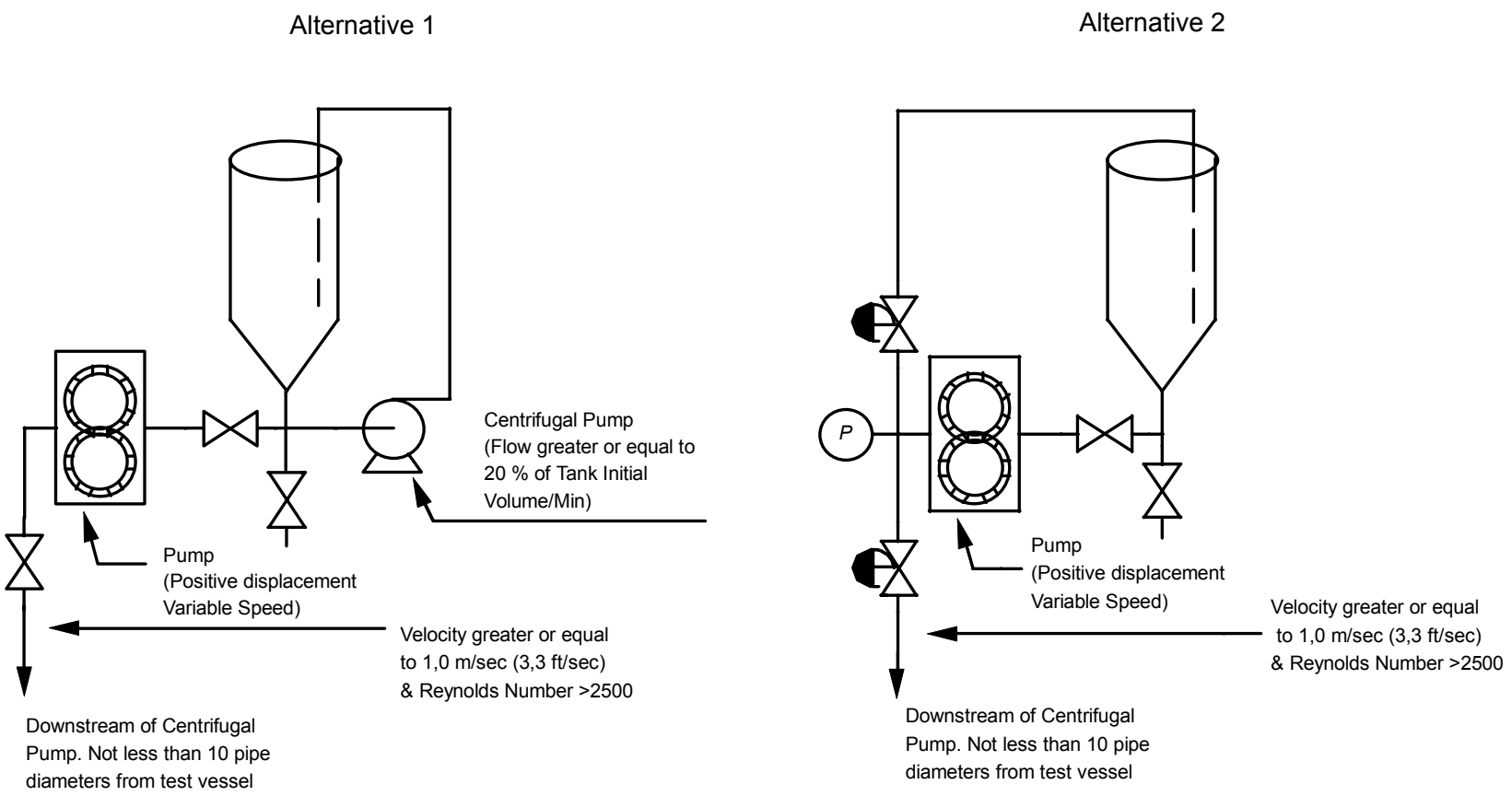

Figure 2 - Solid-contaminant injection facility

5

MANDATORY TEST PROCEDURES

5.1 GENERAL

Microfilter elements shall be tested in a single-element test vessel and duplicate tests performed.

In all tests, clean-up filter/coalescers, filter monitors and/or clay-treatment may be used downstream of the test vessel to prevent fuel storage contamination.

5.2 MECHANICAL SPECIFICATION APPROVAL

The test elements shall be examined to confirm that they comply with the mechanical specifications given in 3.2. A full set of elements for the qualification tests shall be critically examined and any having visual defects are to be noted and rejected. On installing an element in the test vessel, a note shall be made of the manufacturer's installation instructions (especially element torque settings) and the ease of assembly, security of the element and sealing methods. The design shall be such as to minimise the possibility of mis-assembly.

5.3 TEST FUEL PREPARATION

The test fuel shall be cleaned by circulating it through the clay filters and clean-up vessel(s). This recirculation shall continue until all additives have been removed. A maximum conductivity of 10 pS/m indicates that all SDA has been removed. The fuel shall then be treated with the required additives for element and vessel testing.

Stadis 450 shall be added to the test fuel at a concentration of 1,0 mg/1. The fuel shall be circulated through the test facility, by-passing the test unit, downstream clay-treatment and filtration units until the fuel/additive system is well mixed. This shall be determined from the stability of fuel conductivity (ASTM D 2624, IP 274) measurements: a change in fuel conductivity readings, taken over a 15 minute interval, less than 10 pS/m indicates that the test fuel is well mixed. The elapsed time from the initial addition of Stadis 450 until the test fuel is well mixed shall be recorded as the mixing time. The conductivity of test fuel containing Stadis 450 shall be greater than 200 pS/m.

DCI-4A shall then be added to the test fuel at a concentration of 15 mg/l.

Once the fuel/additive system is well mixed (recirculation after DCI-4A at least as long as the mixing time), the test vessel shall be slowly filled with fuel. Any leaks shall be noted and eliminated. During the vessel filling operation there shall be no appreciable fuel flow out of the vessel.

5.4 PERFORMANCE TESTS

With the exception of the environmental tests (5.4.5), all single element test runs (1-4), shall be conducted twice.

All analytical testing shall be carried out in accordance with the latest edition of the relevant ASTM or IP Test Method Books. A schedule of analytical testing required for the qualification tests is given in Annex B.

5.4.1 Run 1 - System conditioning and media-migration check

Test fuel shall be passed through the test element at the manufacturer's proposed rated flow for 45 minutes.

Immediately after fuel flow is established, an effluent sample shall be taken according to ASTM D 2276 (IP 216). A sample volume of 5 litres is required. A similar sample shall be taken 30 minutes later. These samples shall be analysed for media migration as described in Annex C.

At the end of this test run the differential pressure of the element at its rated flow and the influent and effluent fuel conductivities shall be determined and recorded.

5.4.2 Run 2 - Filtration rating qualification

This test run shall be carried out immediately following Run 1 (5.4.1) on the element used in that run. The flow rate shall be the same as Run 1. The appropriate test dust (see 4.3) shall be injected into the fuel stream according to the requirements of 4.3.2, to produce a fine solid dispersion at a concentration of 50 mg/1 of fuel. The run shall be continued until a differential pressure of 150 kPa (22 psi) is achieved. (There is no test duration criteria for this run.) Downstream fuel solids contents shall be measured throughout the run using appropriate membranes according to the element rating (described in 3.1.1 and Annex D) at the following times:

1, 7 and 15 minutes and every 10 minutes thereafter.

The membranes shall be analysed gravimetrically for solids by the method in ASTM D 2276 (IP 216) and Annex D. Results shall comply with the effluent limits stated in 3.1.1 to meet this specification.

Effluent fuel conductivity shall be recorded at 10 minute intervals together with the element differential pressure and the fuel temperature. At no time during the qualification test runs shall the fuel downstream of the filter system have a conductivity less than 100 pS/m (100 cu). Because this requirement controls the impact of elements on a safety-related fuel property, fuel may not be readditized with Stadis 450 to increase effluent conductivity.

After 60 minutes' run time or at a differential pressure of 100 kPa (14,5 psi) whichever is sooner, the main pump and solids injection shall be stopped and both restarted 1 minute later. A gravimetric membrane sample shall be taken as soon as the flow is restored.

At the end of the test the element shall be removed from the test vessel, critically examined and its appearance reported.

5.4.3 Run 3 - Solids interception test at 50 % of rated flow

A new element shall be installed for this test. The test shall be carried out in a similar manner to Run 2 but at a flow rate of 50 % of rated flow for 75 minutes. The dirt concentration, run parameters and performance requirements remain the same as Run 2. All performance data shall be reported including test element appearance as in Run 2.

5.4.4 Run 4 - Water resistance test

A new element shall be installed for this test. The test is a repeat of Run 2 (with the appropriate test dust) but with the injection of water upstream of the main pump at a rate of 0,01 % vol. of the test flow rate. All performance data shall be reported as in Run 2.

At the end of the test the element shall be removed from the test vessel, critically examined and its appearance reported.

5.4.5 Run 5 - Fluid compatibility tests

(Note: also referred to as environmental tests)

These tests shall be performed by soaking elements in each of three different compatibility test fluids as follows:

(a) Jet A/A-1 containing 3,0 mg/1 Stadis 450.

(b) Toluene/iso-octane 30:70 (volume ratio) mixture.

(c) Jet A/A-1 containing 3,0 mg/l Stadis 450 + 0,2 % (by volume) Di-EGME[11].

11 Diethylene glycol monomethyl ether, also known as fuel system icing inhibitor (FSII).

In addition, the purchaser may require a further optional test to be performed in compatibility test fluid (d) Jet A/A-1 containing 3,0 mg/l Stadis 450 + 23 mg/l HiTEC 580.

The volume of liquid used in each test shall be 5 times the volume of a solid object having the same outside dimensions as the test element.

Each element shall receive two sequential 336 hour soaks with a 4 hour drainage period between each soak period. The exception to this is Di-EGME, which requires only a single 336 hour soak period. One litre reference samples of test fluids (a) and (c) shall be stored for comparative testing at the end of the soak test periods. In addition a one litre reference sample is required for the optional test fluid (d), if this test is specified by the purchaser.

These tests are performed only once.

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

(a) identical and have non-contaminating sealable lids or caps;
(b) of such dimensions that the test specimen is totally immersed in the test fluids;
(c) inert to the test fluids (e.g. aluminium or stainless steel containers would be suitable). Note: Since the test fluids are light sensitive, it is recommended that during the soak period, the containers be kept in a dark enclosure, and
(d) thoroughly rinsed with the respective test fluid before proceeding.

The analysis schedule for the resultant liquids is summarised in Table 1. Results shall be reported in a form similar to that shown in Table 2 together with full refinery release certificates for the jet fuel.

Note: the reference sample is analysed at the start and end of the test period.

5.4.6 Element structural test

An element shall be loaded with dirt until a differential pressure of 500 kPa (72,5 psi) is achieved. It shall not be necessary to carry out sampling and analyses or record run details. The pressure of 500 kPa shall be maintained for a period not less than 5 minutes after which time the element shall be removed from the vessel and visually assessed for damage (e.g. rupture of the element or bypassing of the seals). The appearance shall be reported.

Table 1 Run 5 - Fluid compatibility testing analysis schedule (5.4.5)

Compatibility Test Fluids	Analysis Required[12]	No. of 336 hr. Soaks
Jet A/A-1 with 3,0 mg/l Stadis 450	ABCD	2
30:70 v/v toluene/iso-octane mixture	ACD	2
Jet A/A-1 with 3,0 mg/l Stadis 450 + 0,2% v/v Di-EGME	C	1
Jet A/A-1 with 3,0 mg/l Stadis 450 + 23 mg/l HiTEC 580	ABCD	2

12 A = Existent gum (ASTM D 381); B = Water reaction (ASTM D 1094) Interface rating only; C = Detailed visual inspection of all component parts; D = Colour (ASTM D 156).

Table 2 Run 5 - Results of fluid compatibility tests (suggested reporting scheme)

A – Existent gum (ASTM D 381)			
Compatibility Test Fluid	**Test Hours**		**Comments**
	0	1st 336 or 2nd 336	
Jet (A/A-1) with 3,0 mg/l Stadis 450			
Reference Sample			
Post element soak	N/A		
Difference	N/A		
30:70 v/v toluene/iso-octane mixture			
Reference Sample			
Post element soak	N/A		
Difference	N/A		
Jet (A/A-1) with 3,0 mg/l Stadis 450 + 23 mg/l HiTEC 580 (OPTIONAL)			
Reference Sample			
Post element soak	N/A		
Difference	N/A		

B – Water reaction test (ASTM D 1094) – Interface rating only			
Compatibility Test Fluid	**Test Hours**		**Comments**
	0	1st 336 or 2nd 336	
Jet (A/A-1) with 3,0 mg/l Stadis 450			
Reference Sample			
Post element soak	N/A		
Jet (A/A-1) with 3,0 mg/l Stadis 450 + 23 mg/l HiTEC 580 (OPTIONAL)			
Reference Sample			
Post element soak	N/A		

C – Detailed visual inspection of all component parts			
Compatibility Test Fluid	**Test House**		**Comments**
	0	1st 336 or 2nd 336	
Jet (A/A-1) with 3,0 mg/l Stadis 450			
30:70 v/v toluene/iso-octane mixture			
Jet (A/A-1) with 3,0 mg/l Stadis 450 + 0,2% v/v Di-EGME			
Jet (A/A-1) with 3,0 mg/l Stadis 450 + 23 mg/l HiTEC 580 (OPTIONAL)			

D – Colour (ASTM D 156)			
Compatibility Test Fluid	**Test Hours**		**Comments**
	0	1st 336 or 2nd 336	
Jet (A/A-1) with 3,0 mg/l Stadis 450			
Reference Sample			
Post element soak	N/A		
Difference	N/A		
30:70 v/v toluene/iso-octane mixture			
Reference Sample			
Post element soak	N/A		
Difference	N/A		
Jet (A/A-1) with 3,0 mg/l Stadis 450 + 23 mg/l HiTEC 580 (OPTIONAL)			
Reference Sample			
Post element soak	N/A		
Difference	N/A		

ANNEX A

UNIT CONVERSION FACTORS

1 US Gal.	3,785 litres
1 litre	0,264 US Gal.
1 Imp. Gal.	4,546 litres
1 litre	0,220 Imp. Gal.
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 in.	0,0254 m
1 dyne/cm	1 mN/m
1 cu	1 pS/m

T °F = 1,8 x T °C + 32

ANNEX B

SCHEDULE OF ANALYTICAL TESTING (5.4)

Table B1 - Effluent fuel sampling schedule and procedures

Sample times	Reference paragraph	Test	Sample size (litres)	No. of samples	Sample method
At start and 30 minutes	5.4.1	Media migration	5	2	ASTM D 2276 and Annex C
45 minutes	5.4.1	Influent and effluent conductivities	1	2	ASTM D 2624
At 1, 7 and 15 minutes and 10 minute intervals thereafter	5.4.2 5.4.3 5.4.4	Effluent solids	5	7 (max)	ASTM D 2276 and Annex D
At 10 minute intervals	5.4.2 5.4.3 5.4.4	Effluent conductivities	1	7 (max)	ASTM D 2624

ANNEX C

LABORATORY ANALYSIS OF MEDIA MIGRATION SAMPLES

The contaminant shall be extracted in the normal manner (5.4.1) and weighed in accordance with ASTM D 2276. It is preferable to use gridded membranes as the grid markings facilitate the subsequent fibre counts.

After weighing, the test membrane shall be placed under a low power microscope (overall magnification about x20) and examined for fibres. For the purposes of this procedure, a fibre is defined as any particle having a length equal to or greater than 10 times its width, and having a length of 100 microns or more.

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

ANNEX D

GRAVIMETRIC MEMBRANE ANALYSIS AND CONTAMINANT REMOVAL EFFICIENCY RATING

To measure the contaminant removal efficiency of a microfilter element, a line sample of fuel is drawn off downstream of the element and passed through a suitable membrane. This membrane is then analysed gravimetrically.

Using the principles described in ASTM D 2276, Annex A2 (IP 216, Annex A), the line sample shall be taken from an upstream-facing probe positioned downstream of the microfilter test vessel. The probe shall be between five and ten pipe diameters from the outlet of the test vessel. Sample pipe layout and size shall be designed to preclude particle settlement in areas upstream of the sampling point.

Membrane type shall depend on the microfilter nominal rating as specified in 3.1.1.

Gravimetric analysis is performed by the method in ASTM D 2276 (IP 216) except that, for microfilters having ratings other than 1,0 µm, the membranes specified in 3.1.1 are substituted for the 0,8 µm membranes required by ASTM D 2276 (IP 216).

Note: It may be convenient to refer to test results from membranes other than 0,8 µm as conforming to API/IP 1590 Annex D versus ASTM D 2276 modified.

Not all available membrane filters are suitable for this application. A list of suppliers who have provided data indicating that their membranes meet the requirements of ASTM RR:D02 1012, (1994) is available from ASTM headquarters. For membrane sizes not qualified by the ASTM research report, membranes closely related (e.g. composition and manufacturing methods) to qualified membranes shall be acceptable.