SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

SAE AIR4057 REV. A

Issued 1986-11
Revised 2000-12
Reaffirmed 2004-12

Superseding AIR4057

Secondary Filters for Fluid System Reliability

1. SCOPE:

This SAE Aerospace Information Report (AIR) discusses the design choices and engineering trade-offs available to the system designer in the efficient selection and application of Last-Chance filters in contrast to main or primary system filters.

1.1 Purpose:

This document explains the use of secondary (or Last-Chance) filters in fluid systems.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AIR844	Sensitization and Corrosion in Stainless Steel Filters
AIR887	Liquid Filter Ratings, Parameters and Tests
AIR888	Fine Wire Mesh for Filter Elements
ARP901	Bubble-Point Test Method
ARP1383	Impulse Testing of Hydraulic Actuators, Valves, Pressure Containers and Similar Fluid System Components
AS4059	Cleanliness Classification for Hydraulic Fluids

3. DEFINITION:

A secondary filter is one most often installed immediately upstream of a fluid system component, and downstream of the primary filter, to provide positive protection only to that component from potential catastrophic failure caused by large particle ingestion. Sometimes several secondary filters are provided in series as integral parts of system components.

4. BACKGROUND:

In theory, large particles that can cause catastrophic failures in a fluid system are stopped by the main system filters. This is true only for the contaminant in the flow path immediately upstream of the filter.

Contaminants are generated and ingested throughout the system, frequently passing through a critical component on their way to the primary or main system filters.

Vast numbers of particles are present in typical fluid systems, and the majority are under 15 µm as can be seen in the cleanliness levels listed in AS4059. This part of the contaminant spectrum is removed by primary or main system filters, which are designed to receive the full system flow and to remove and retain large amounts of fine contaminants. They may include accessory devices such as bypass valves, automatic shutoffs, differential pressure indicators as well as other features for maintenance and system reliability. Primary filters are traditionally placed in the pump discharge lines, system return lines, and pump case drain lines.

The fine particles removed by the primary filter are considered to be a major factor in fluid system component wear and the removal of the fine particles has been demonstrated as useful in controlling wear rates.

5. FUNCTION OF SECONDARY FILTERS:

Well filtered fluid systems, with respect to main system filters, are still subject to occasional, sudden, catastrophic component failure caused by large particles, which can enter the system, or be released downstream of the primary or main system filters. The function of secondary filters is to protect system components against ingression of large particles released in the system.

6. SOURCES OF CONTAMINATION TO SECONDARY FILTERS:

Large, potentially destructive particles such as machining chips, braze and weld flash, core sand, gasket material, TFE tape shreds, gear tooth wear particles, wiper fibers, carbon particles, burrs that fail at their attachment points, and O-ring chips can enter the system in any of the following ways:

a. Built into new or recently overhauled components.
b. From each make or break of connections (e.g., the assembly of ordinary line fittings).
c. By direct introduction when lines are opened for maintenance.
d. Break-in wear of components.
e. During the introduction of make-up fluid.
f. Abnormal wear of moving components.
g. Through the bypass valve of a main system filter when the filter is clogged or bypasses during cold start.
h. As the result of fluid breakdown caused by local overheating.

It should be recognized that large particle fluid system contamination is random and not statistically predictable. Large particles are released downstream of primary filters throughout the life of the system and may be the result of built-in, maintenance generated, or duty cycle released contamination.

Because of this random introduction, the counts of large particles in AS4059 may not be representative of actual systems contaminant levels. Wherever large particles come from, the most practical way to prevent large particle caused component failure is through the proper application of secondary filters, and it is important that consistent standards for sizing and design be used by system designers.

7. APPLICATION OF SECONDARY FILTERS:

7.1 Properly designed secondary filters increase the overall performance of a fluid system by improving the reliability of major components without causing system problems themselves. When properly applied, a secondary filter may last the life of the hose component without requiring any maintenance itself. If a component failure has occurred upstream, which results in a major contamination release, the Last-Chance filter helps to prevent secondary failures which frequently follow in chain reaction.

7.2 Secondary filters are most effective when installed at the inlet of the components to be protected, so that the entire flow to the component is filtered. Components vary widely in complexity (a multi-function servo actuator or a simple orifice or a restrictor or a poppet type relief valve are examples) and should be analyzed for contaminant sensitivity on an individual basis, to achieve the best locations and removal ratings for their secondary filters.

7.3 The designer should also recognize that complex components may already contain integral secondary filters supplied as part of subtier components (precision orifices with small built-in screens for example) and that these devices must be recognized and compensated for in the selection of a secondary filter to protect the entire component. In this case the removal rating of the larger inlet filter should be finer than that of smaller downstream screen to ensure adequate life of the smaller filter. Another way of saying this is when several secondary filters function in series in the same component, it is important that their removal ratings become progressively coarser to prevent plugging of the downstream, and generally physically smaller, filters.

8. SECONDARY FILTER DESIGN CHARACTERISTICS:

Some of the characteristics which should be considered are:

8.1 Location within the system and within the component to be protected.

8.2 Adequate particulate protection level (maximum pore size glass bead rated and bubble point tester) to suit the component to be protected.

8.3 Filtration level coarse enough to prevent clogging by fine particles normally removed by the primary filter or by the next higher tier (upstream) secondary filter.

8.4 Pressure vessel ratings of filter housing.

8.5 Low pressure drop at normal flow rates and temperatures.

8.6 Does not exhibit media migration.

8.7 Filter element collapse (or burst) differential pressure rating.

8.8 Acceptable pressure drop at cold start conditions.

8.9 Long service life and high corrosion and fatigue resistance.

8.10 Small size, weight, and geometry.

8.11 Exclusion of elastomers in coarse Last-Chance filters for extended seal maintenance.

9. SECONDARY FILTER SUGGESTED LOCATIONS:

9.1 Immediately upstream of the component to be protected so that all of the flow entering is filtered to the desired level.

9.2 Inside the component as an integral part of the assembly, to filter all of its flow, or to filter only that portion of the flow necessary to protect a particularly vulnerable part of the device.

9.3 At the outlet of a contamination-sensitive component that sees reverse flow.

9.4 At the outlet of a known generator of large particle contamination to prevent circulation in the system. The effect of possible reverse flow will have to be considered.

9.5 Upstream of important, but seldom used or dead ended components.

10. SECONDARY FILTER REMOVAL RATING:

To protect a particular component or function, the critical clearance (perhaps a valve opening or orifice diameter) must be known, and a removal rating selected that is some reasonable fraction of this opening. A frequently recommended removal rating is 1/3 the size of the opening to be protected so that two particles arriving at the same time are not likely to cause a malfunction.

At the same time, a conscious effort must be made to select a filtration level that does not infringe on the upper limit of the main system filter removal rating. Should this happen, the small secondary filter could clog, reduce system performance, and cause lower system reliability and increased maintenance. It requires design discipline to accept a secondary filtration level that leaves a small possibility of an intermediate particle causing a problem while avoiding the higher probability of premature clogging of the secondary filter.

General recommendations are shown in Table 1:

TABLE 1

Removal Rating of Main System Filter	Removal Rating of Secondary Filter
Below 3 µm	35 µm absolute
3-30 µm absolute	70 µm absolute
31-100 µm absolute	150 µm absolute
Greater than 100 µm absolute	250 µm nominal

In many cases, 250 µm nominal rating (approximately 0.010 in) is adequate protection for orifices and other relatively large openings and is particularly useful for third or fourth tier protection (third and fourth filters in series).

Absolute filtration ratings, which are easily bubble point tested, should be specified so as to guarantee the maximum size of hard spherical particles passed by the filter. An added benefit of the fixed pore size (sintered mesh or other proven media) filter is the control of media migration. If any part of the filter is released downstream the purpose of the Last-Chance filter is defeated. Unfortunately, filters coarser than 200 µm absolute cannot be accurately bubble point tested on a production basis.