SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

SAE AIR1047 REV. D

Issued 1968-01
Revised 2000-10
Reaffirmed 2013-01

Superseding AIR1047C

A Guide for the Selection of Quick-Disconnect Couplings for Aerospace Fluid Systems

RATIONALE

AIR1047D has been reaffirmed to comply with the SAE five-year review policy.

FOREWORD

Changes in this revision are format editorial only

INTRODUCTION

Aerospace quick-disconnect coupling applications include three classifications of usage which dictate the relative importance of most design factors. The classifications of quick-disconnect usage are: ground support equipment, air vehicles, and space vehicles. The level of required performance required generally increases in the same order of application.

This report includes requirements and considerations for quick-disconnect specification and design. Not all of them will apply to a particular coupling requirement. Their relative importance will vary with usage classification and fluid media in a broad sense. Each application must then be examined by the user and manufacturer to obtain the optimum design.

Weight and envelope dimensions are often the reason a specialized design is required. Designers are well aware of the economics of dead weight versus payload capacity in aerospace vehicles.

This also applies to ground support equipment when a hose must mate with a coupling half attached to the aerospace vehicle. In the latter case, the coupling half must be as light as possible while performing to its specified requirements.

The relationship between design factors and fluid media is charted in Table 1. The table indicates which subsequent paragraphs should be reviewed for a particular application. The final specification and design will depend on the level of performance required as dictated by the end use.

TABLE 1 - Factors to be Considered in Quick Disconnect Specification

□ - APPLICABLE
Δ - OPTIONAL
O - NOT APPLICABLE

			APPLICATION										
	PARA.	DESIGN FACTORS	FACTOR AFFECTS WEIGHT	GROUND SUPPORT EQUIPMENT	AEROSPACE HYDRAULIC	HYDRAULIC RETURN	FUEL AND OIL	HYPERGOLICS	COOLANT	CRYOGENIC	PNEUMATIC	BREATHING OXYGEN	
FUNCTIONAL CONSIDERATIONS SECTION 5	5.2	CONNECTION / DISCONNECTION TYPE	□	□	□	□	□	□	□	□	□	□	
	5.4	PRESSURE DROP	□	□	□	□	□	□	□	□	Δ	Δ	
	5.5	IMPULSE SURGE LIFE	□	□	□	Δ	O	O	O	□	O	O	
	5.6	CONNECT INDICATION	□	□	□	□	□	□	□	□	□	□	
	5.7	POLARIZING	□	Δ	Δ	Δ	Δ	□	Δ	Δ	Δ	□	
	5.8	PRESSURE CAPS	□	Δ	□	O	O	□	O	□	Δ	Δ	
	5.9	DUST CAPS, DUST PLUGS	□	□	□	□	□	□	O	□	□	□	
	5.10	FLUID COMPATABILITY	□	□	□	□	□	□	□	□	□	□	
	5.10	LUBRICATION	O	Δ	O	O	O	□	□	□	□	□	
	5.11	HEAD PRESSURE	□	□	□	O	Δ	□	Δ	□	□	Δ	
	5.12	FLUID LOSS AT DISCONNECT	□	□	□	□	□	□	□	□	O	O	
	5.13	AIR INCLUSION DURING CONNECTION	□	□	□	□	Δ	□	□	□	O	O	
	5.14	RELIEF VALVING	□	Δ	Δ	Δ	O	O	O	O	Δ	Δ	
	5.15	LEAKAGE CONNECTED/DISCONNECTED	O	□	□	□	□	□	□	□	□	□	
	5.16	MISALIGNMENT DURING CONNECTION	□	□	□	□	□	□	□	□	□	Δ	
	5.17	SIDE LOAD PERFORMANCE	□	□	□	□	□	□	□	□	□	□	
	5.18	SEALS	□	□	□	□	□	□	□	□	□	□	
ENVIRONMENTAL PERFORMANCE FACTORS SECTION 7	7.2	PRESSURE VACUUM	□	□	□	□	□	□	□	□	□	□	
	7.3	TEMPERATURE RANGE	□	□	□	□	□	□	□	□	□	□	
	7.4	VIBRATION	□	Δ	□	□	□	□	□	Δ	□	Δ	
	7.4	SHOCK	□	□	□	□	□	□	□	Δ	Δ	Δ	
	7.4	IMPACT RESISTANCE	□	□	□	□	□	□	Δ	Δ	Δ	Δ	
	7.4	ACCELERATION	□	O	□	□	□	□	□	Δ	Δ	Δ	
	7.4	VIBRATION WITH IMPULSE	O	Δ	Δ	Δ	□	Δ	O	O	□	Δ	
	7.5	RADIATION	□	O	Δ	Δ	O	Δ	Δ	Δ	Δ	Δ	
	7.6	HUMIDITY	O	Δ	Δ	Δ	Δ	Δ	Δ	□	□	□	
	7.7	FUNGUS RESISTANCE	O	Δ	O	O	Δ	Δ	O	□	O	□	
	7.8	CORROSION	□	□	□	□	□	□	□	□	□	□	
8		END FITTING TYPES	O	□	□	□	□	□	□	□	□	□	
ADDITIONAL CONSIDERATIONS SECTION 9	9.1	INSTALLATION	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
	9.2	INTERCHANGEABILITY	O	O	O	O	O	O	O	O	O	O	
	9.3	CLEANING	O	□	□	□	□	□	□	□	□	□	
	9.3	INSPECTION	O	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
	9.3	QUALITY CONTROL	O	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
	9.4	IDENTIFICATION	O	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
	9.5	MAINTAINABILITY AND RELIABILITY	□	□	□	□	□	□	□	□	□	□	
		CUSTOMER DOCUMENT POLICY	O	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
		PRE-PRODUCTION TESTING	O	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
		QUALIFICATION TESTING	O	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	
	9.6	COST	□	□	□	□	□	□	□	□	□	□	

1. SCOPE:

The factors involved in the selection of a quick-disconnect are grouped into the following classifications for the purpose of discussion:

a. Functional considerations.
b. Weight considerations.
c. Environmental performance factors.
d. End fitting types.
e. Additional considerations.

A quick-disconnect coupling as used in this AIR is one that can be rapidly and repetitively connected and disconnected without excessive fluid loss.

The relative importance of the design factors depends upon the fluid medium of the particular system in which quick-disconnect is to be used. The effect of the fluid media on each factor is discussed in this report where applicable.

1.1 Purpose:

The purpose of this AIR is to guide users in the proper selection of quick-disconnect couplings for their specific application in fluid systems.

2. RELATED DOCUMENTS:

A list of related specifications and standards is attached as Appendix A of this document. The latest revision should be used.

3. FUNCTIONAL CONSIDERATIONS:

3.1 General:

3.1.1 Design factors vary according to the specialized functional considerations of the application.

3.1.2 This section excludes discussion of environmental performance, which is required for product qualification. See Section 5.

3.1.3 Topical points in each subsequent section point out variations due to specific functional considerations, including reliability and human engineering.

3.2 Connecting and Disconnection Types:

3.2.1 Push-Pull: Push-Pull types are as follows:

Class “A” – Those which require axial motion to connect and disconnect.

Class “B” – Those which require axial motion to connect plus rotational motion to lock, and axial motion to disconnect.

Class “C” – Those which require axial motion to connect, plus rotation to lock and unlock, and axial motion to disconnect.

3.2.2 Threaded: Threaded types are as follows:

Class “A” – Those which employ a fast lead (multiple) thread to enable connection and disconnection with a minimum number of turns.

Class “B” – Those which employ a standard (straight lead) thread to enable connection and disconnection with a minimum number of turns.

3.2.3 Rack and Panel:

3.2.3.1 The rack and panel design contains one or more couplings of which separate halves are installed on a rack and panel. The locking mechanism is independent of the coupling.

3.2.4 Remotely Actuated:

3.2.4.1 Remotely actuated designs are capable of connection and disconnection by other means than direct manual actuation, but also may include manual actuation provisions.

3.2.4.2 Typical classes of remotely actuated couplings are as follows:

a. Cartridge (SQUIB)
b. Lanyard
c. Electric
d. Hydraulic
e. Pneumatic
f. Combination of any of the above types

3.2.5 Special: One type of coupling in this category is that which permits separate throttling or shutoff of the fluid without disengaging the coupling. This coupling requires axial motion to engage plus rotation to lock, and a separate motion to open and close the poppets, and to close the poppets, and rotation to unlock and axial motion to disengage.

3.3 Selection Criteria:

3.3.1 Adequate hand(s) clearance must be provided for those coupling types which require manual connection and disconnection.

3.3.2 Maximum allowable forces or torques, or both, required for connection and disconnection should be specified. (These are dependent on line and system pressure at connection.)

3.3.3 Separation and connection forces must be considered in the rack and panel type.

3.3.4 Limits and types of power sources should be specified.

3.4 Pressure Drop:

3.4.1 Low pressure drop is equated to increased diameter or length, or both, and, therefore, greater envelope. Valving design is a function of pressure drop.

3.5 Impulse/Surge Life:

3.5.1 Impulse life is generally required for hydraulic service couplings. Where impulse is not a design factor, peak system pressures or flow surges should be considered.

3.5.2 Impulse life varies with system temperature-pressure profiles, pressure rise rate and number of cycles.

3.6 Connect Indication:

3.6.1 Visual: Tape, paint, anodize two-tone (for example, strip of a secondary color, covered or uncovered) denotes a completely connected coupling.

3.6.2 Mechanical: Extendable pins or balls.

3.6.2.1 The connection indicator(s) should be of such a nature that any false indication of complete connection will be precluded.

3.6.3 Electrical Switches:

3.6.4 Combination: Electrical, visual, and mechanical type indicators may be used in combination.

3.7 Polarizing:

Prevention of Cross Connection:

3.7.1 Polarizing may be required where many lines of the same size attach in close proximity.

3.7.2 Polarizing may be required to prevent mixing of hypergolic fuels and their oxidizers.

3.7.3 Polarizing may be required to prevent errors in line connection during component replacement.

3.8 Pressure Caps:

Pressure caps are usually required for ground service connections on high pressure systems. They include secondary overall seals for reliability, which is often necessary for reliability assurance aerospace applications.

3.9 Dust Caps, Dust Plugs:

Dust caps and dust plugs protect coupling halves from contamination when disconnected. They may use the same coupler mechanism as the coupling, or friction fit resilient material where allowable. Pressure caps, where used, may serve as dust caps.

3.10 Fluid Compatibility:

3.10.1 Fluid media, temperature, and system pressure governs the choice of sealing materials, lubricants, and the choice of plastic or metallic parts, or both.

3.10.2 The selection of metallic components, sealing materials, and lubricants is governed by fluid media and cleaning requirements under ambient and system temperature and pressure conditions.

3.11 Head Pressure (During Connect and Disconnect):

3.11.1 Head pressure is a direct influence on both valve and coupler design (see 3.14).

3.11.2 The need for balanced valving is dependent on head pressure, line size, coupler design freedom, and allowable connection force/torque.

3.12 Fluid Loss at Disconnect:

Minimum fluid loss is desirable with all liquid media. Fluid loss is more critical inside the vehicle, particularly with volatile liquids.

3.13 Air Inclusion During Connection:

Minimum air inclusion during connection is desired, especially on hydraulic systems.

3.14 Relief Valving:

3.14.1 Relief valving is used to relieve pressure due to fluid expansion in a closed system when the coupling halves are disconnected. A specialized type is actuated by the mating half and allows pressure decay in a closed system, with resulting small fluid loss, to permit connection.

3.14.2 Pressure release valves may be designed into a coupling to allow connection against a head pressure up to operating pressure. They are only usable in closed systems since fluid loss occurs during actuation. They are actuated by the mating half.

3.14.3 When pressure balanced valve couplings are used, pressure relief valves are not necessary to actuate release valves.

3.14.4 Thermal relief valves are designed to allow a small amount of system fluid to escape to prevent excessive pressure build up in a closed system when the fluid is subject to expansion.

3.14.5 High flow relief valves may be provided to prevent equipment damage in a hydraulic system which is closed due to coupling disconnect.

3.14.6 High pressure relief valves may also be high flow relief valves. High flow relief valves generally require larger valving than do thermal or pressure relief valves.

3.15 Leakage Connected/Disconnected:

The specification of allowable leakage is usually classified as zero. Zero leakage is a misnomer. Leakage is quantitative and should be specified as the maximum allowable for a specific set of conditions.

3.16 Misalignment During Connection:

Specify required misalignment provisions to compensate for dimensional tolerances such as those entailed in connection of rack and panel assemblies.

3.17 Side Load Performance:

3.17.1 This requirement is dependent on the hose installation in a given application. The presence of side loading affects coupler design which in turn controls the allowable change in seal compression due to side loading. The condition must be specified when present in new applications since it limits coupler design freedom.

3.17.2 Excessive side loads should be avoided. The presence and magnitude of side loads, because they affect coupling design, should be specified when they are unavoidable.

3.18 Seals:

3.18.1 Seal configuration should permit repeated connection and disconnection at maximum allowable misalignment without seal damage.

3.18.2 Seals should be adequately contained to preclude washout under high flow or surge conditions.

3.18.3 Seals should be located so that they are not subject to ready damage with the coupling disconnected.

4. WEIGHT CONSIDERATIONS:

4.1 General:

4.1.1 This section is a discussion of design features that influence weight. The effect is often indirect because it relates to other factors which must also be present or absent in a set of design requirements.

4.1.2 A primary consideration in the design of aircraft and space vehicles is the useful payload capability. Structure, accessories, powerplants, and hardware are all designed to perform their function with the minimum weight. The weight savings on each component is reflected in increased payload. Several design factors in quick disconnect design add weight to the product. Each factor which influences weight should be analyzed individually for an application to determine its value with respect to weight. Design factors which influence weight directly or indirectly are noted in the first column of Figure 1. A more complete discussion of each factor may be found in the subsequent sections on Functional Considerations, Section 3, and Environmental Performance Factors, Section 5.

4.2 Coupler Design:

4.2.1 Threaded couplers are generally lighter than push-pull and quick turn couplers.

4.2.2 Rack and panel integration may save weight on the total package.

4.2.3 Remote actuation, where necessary, will add weight due to the additional mechanism. On ground service equipment (GSE) applications, the mechanism may be incorporated into the ground half at no penalty to the airborne vehicle.

4.2.4 Self-sealing couplings are generally heavier than non-self-sealing types.

4.3 Pressure Drop:

A coupling with excellent pressure drop performance will generally be larger and heavier than a compact design, which has more pressure drop resulting from envelope restrictions.

4.4 Impulse Life:

Hydraulic couplings with a high impulse life requirement will require heavier cross-sections than an optimum design without this requirement.

4.5 Pressure:

The operating pressure range of a coupling directly affects the choice of material and wall thickness.

4.6 Connect Indication:

A mechanical or electrical method of indicating complete connection will add weight directly. Color coding in various forms would not affect weight.

4.7 Polarizing Devices:

The addition of a device to prevent cross-connection may add weight as well as increase the envelope to accommodate the device.

4.8 Pressure Caps:

Pressure caps which are attached to their respective coupling half and are carried on a vehicle will add weight.

4.9 Dust Caps, Dust Plugs (see 4.8):

4.10 Fluid Compatibility:

Fluid compatibility is a direct factor which influences the choice of basic metals and sealing materials. Fluid compatibility must include lubricant compatibility.

4.11 Head Pressure:

Connection and disconnection against a head pressure will affect the design requirements of valving. At higher pressures, the valves may have to be pressure balanced to allow connection without undue force or torque. It should be specified whether one half or both halves are pressurized during connection and disconnection.

4.12 Relief Valving:

The addition of a relief valve may cause a slight increase in weight. It should be noted that a close tolerance on relief pressure or high flow can result in a larger package and a more complex design.

4.13 Functional Life:

The number of connection cycles required of a coupling is an indirect weight factor because it affects the sophistication of the design. Material choice with respect to wear is also involved.

4.14 Temperature Range:

The fluid and ambient temperature range directly affects the choice of material and wall thickness.

4.15 Vibration, Shock, Acceleration and Impact:

Resistance to the above environmental conditions directly affects the choice of materials and wall thickness.

4.16 Corrosion:

Resistance to corrosive environments may dictate the use of special materials or protective coatings, or both, where it would not otherwise be required.

5. ENVIRONMENTAL PERFORMANCE FACTORS:

5.1 General:

5.1.1 The factors discussed in this section are dependent on application and form the content of environmental testing for each new design. The primary purpose of this section is to review the established classes of performance and the range of values found in aerospace applications.

5.1.2 Specifications should reveal the range of values for both operating fluid media and external ambient of temperature and pressure.

5.2 Pressure/Vacuum:

5.2.1 Hydraulic pressure classes of MIL-C-25427A are as follows:

Class 600 – 600 psig operating
Class 3000 – 3000 psig operating

5.2.2 In practice, the pressure and vacuum requirements may vary from a near perfect vacuum to 10,000 psig in the disconnected mode. In the connected mode, the external pressure may range to 6000 psi. If external pressure exceeds internal pressure in the disconnected mode, differential pressure forces must be considered.

5.3 Temperature Range:

5.3.1 Temperature classes of MIL-H-8775 (hydraulics) and MIL-P-8564 (pneumatics) are:

Type I -65 to 160 °F
Type II -65 to 275 °F

Temperature class of MIL-H-8890 (hydraulics) is:

Type III -65 to 450 °F

5.3.2 The current state-of-the-art deals with temperatures from near absolute zero to over 2000 °F. The limit range of non-metallic seals is up to 450 °F. Metallic seals are needed above 450 °F, except in very special applications.

5.4 Vibration, Shock, Acceleration, Impact:

The above requirements are directly related to the levels experienced by the vehicle application. Standard test levels are specified in MIL-E-5272 and MIL-STD-810 and should be selected on the basis of system requirements.

5.5 Nuclear or Gamma Radiation:

The primary effect of radiation on couplings is on non-metallic seals. Irradiation causes degradation, but specific levels can be met with certain materials.

5.6 Humidity:

Most coupling materials with the exception of the seals are not affected by humidity. Under certain conditions of humidity and temperature, the function may be affected due to frost formation. This is applicable to cryogenic systems.

5.7 Fungus Resistance:

Most coupling materials are not affected by fungus and will not support their growth. The use of fungus supporting materials is discouraged.

5.8 Corrosion:

Consideration should be given to the environmental conditions to be expected in service. Particular attention should be given to conditions which could cause the following:

a. General corrosive attack
b. Stress corrosion
c. Intergranular corrosion
d. Embrittlement
e. Galvanic corrosion
f. Other types of corrosive action

6. END FITTING TYPES:

6.1 The following is a list of various end configurations which are used for the installation of coupling halves:

6.1.1 Standard:

a. Flared per MS33656 and MS33657
b. Precision flared per MS24385 and MS24386
c. Flareless per MS33514 and MS33515
d. Flanged per MS24335
e. Boss per MS33649
f. Dynamic beam per MIL-F-85421

6.1.2 Special: Couplings can accommodate special end configurations but their use should be avoided in the interest of standardization. Procuring activity may specify desired fitting.

7. ADDITIONAL CONSIDERATIONS:

7.1 Installation:

7.1.1 Factors to be considered in the installation of a coupling are:

a. Accessibility to determine that the coupling is properly engaged.
b. Clearance from adjacent objects for operation.
c. Elbows, tees, and various fittings to reduce side load.
d. The need for provisions to prevent hose kinking.
e. Possibility of incorrect connection (for example, pressure to return).

7.2 Interchangeability:

7.2.1 There is no interchangeability between different manufacturers' coupling halves, except where a military detail design exists for that specific coupling half.

7.2.2 Interchangeability is achieved between different manufacturers' complete coupling assemblies only where their respective assemblies are designed to meet the same performance requirements.

7.3 Cleaning:

Cleaning considerations are as follows:

a. Cleanliness levels are directly related to system requirements. In addition, the user should specify the particular cleanliness level required.

b. The user should specify what lubricants are compatible with fluids and materials.

c. Consider wear and fluid contamination after acceptance testing.

7.4 Identification:

The part(s) should be individually and permanently identified.

7.5 Maintainability and Reliability:

Maintainability and reliability considerations are as follows:

a. Care should be taken that no misconnection can occur which would permit valves to remain closed even though the coupling appears to be connected.

b. Special tools should be avoided except where accessibility and force requirements dictate their usage.

c. Replacement of any internal parts of the coupling should conform with the supplier's instructions.

7.6 Cost:

Cost consideration are as follows:

Quick disconnect couplings should be selected with full consideration for simplicity of design, reliability, and considerations for the effects of high levels of cleanliness.

PREPARED UNDER THE JURISDICTION OF
SAE SUBCOMMITTEE G-3A, AEROSPACE COUPLINGS

APPENDIX A

TABLE A1 – Specifications and Standards Relating to Quick-Disconnect Couplings

Procurement Specification	Related Standard	Application	Pressure
SAE ARP1709 Coupling Assembly, Hydraulic, Self-Sealing, Quick-Disconnect		Hydraulics	Med. High
SAE ARP4157, Coupling Assemblies, Hydraulic, Self-Sealing, Quick-Disconnect		Hydraulics	5000 and 8000 psi
MIL-C-62005 Coupling Automotive Air Brake Lines: Quick Disconnect	MS35746 Coupling Automotive Air Brake Lines	Air	Low
None	MS21957 Couplings Quick Disconnect Air Connection, Bulkhead Fitting End 1/2 Tube Size	Air	Low
MIL-C-19179 Coupling Assembly Quick Disconnect Fuel	MS26549 Nipple Quick Disconnect 2-1/2 Inch Pressure Fuel Servicing, Flange Type	Fuel	Low
	MS26550 Coupling Quick Disconnect 2-1/2 inch Pressure Fuel Servicing Nozzle to Hose	Fuel	Low
	MS26552 Nipple, Quick Disconnect 2-1/2 inch Pressure Fuel Servicing Open Flow, Wrenching Type	Fuel	Low
MIL-C-25162 Coupling Reception Flight Pressure Refueling, Type MA-2	MS24355 Coupling Reception Type MA-2, Flight Pressure Refueling Assembly of	Fuel	Low
MIL-A-25676 Adapter, Pressure Lubricating, Oil Servicing Aircraft	MS24476 Adapter Pressure Lubricating Oil Servicing Aircraft	Oil	Low
	MS24480 Cap, Lubrication Fitting, Protective, Pressure Servicing Adapter	Oil	Low