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SAE LAND SEA AIR SPACE

AEROSPACE RECOMMENDED PRACTICE

Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

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AEROSPACE GROUND EQUIPMENT CRITERIA FOR UMBILICAL SYSTEMS PROPELLANT QUICK-DISCONNECTS

FOREWORD

This Aerospace Recommended Practice provides basic criteria for Aerospace Ground Equipment umbilical systems propellant quick-disconnect couplings in the transfer of liquids and gases. The umbilical systems defined in this document relate to configurations for certain types and classes of weapon and space vehicles.

These recommendations are considered currently applicable as a guide, and become subject to update by the committee due to continuing development within the Aerospace industry.

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1. PURPOSE

This document presents the technical aspects for remotely actuated, umbilical systems quick-disconnect couplings. These umbilical systems couplings are used in connecting launch-complex servicing lines to a vehicle for the transfer of liquid and gas compounds and mixtures.

2. SCOPE

This Aerospace Recommended Practice includes the following areas: basis for system requirements; selection of materials coupled with hazards and safety; configuration of design; system operation; and evaluation testing.

3. SYSTEM REQUIREMENTS

In the requirements of this ARP, two operational procedures predominate. One is a remote connect and disconnect immediately prior to vehicle lift-off. The other is a manual connect, with flyaway lanyard disconnect at vehicle lift-off. Refer to Figure 1.

A major consideration in connect (reconnect) by remote command is the relative motion or displacement between the vehicle and umbilical boom and tower. Any mechanism designed to reconnect the ground system to the vehicle connector must compensate for relative motion resulting from thermal expansion and wind loads acting on the vehicle and umbilical boom.

Manual connect and lanyard flyaway disconnect at lift-off eliminates the problem of reconnecting to the vehicle. The use of flexible transfer lines at the interface simplifies the problems of divergent motions. However, the length and weight of transfer lines, the undesirability of drastic flexure in a fluid line, the loads imposed on the vehicle, the reliability of absolute disconnect, and the necessity of retracting clear of the vehicle flight path must be considered.

In relation to the remote control method of connection and positive reliable disconnect which occur at precisely a programmed point in time, certain desirable parameters present the following tradeoff advantages:

1. The ground-half couplings and terminal transfer system are supported by the positioning/actuating mechanism.

2. An opportunity exists for optimizing the operational sequencing relative to time of disconnect to first motion of the vehicle.

3. Fluid entrapment caused by a flexible catenary geometry can be avoided by direct routing.

4. Vehicle structure weight penalties are reduced to elimination of side loads imposed at the air-half connector.

5. The same side loads imposed by a flexible catenary system are greatly amplified at first stage by mechanical vibration and acoustic impact; they must be accounted for by a higher stressed, less optimum design.

6. The dynamic forces generated by actions of disconnect and withdrawal can be lessened by the controlled and predictable action of a mechanical actuation and withdrawal system.

7. The chances of accidental disconnect are reduced and, should such an incident occur, the effect can be rectified immediately; this is not possible with the flexible catenary approach.

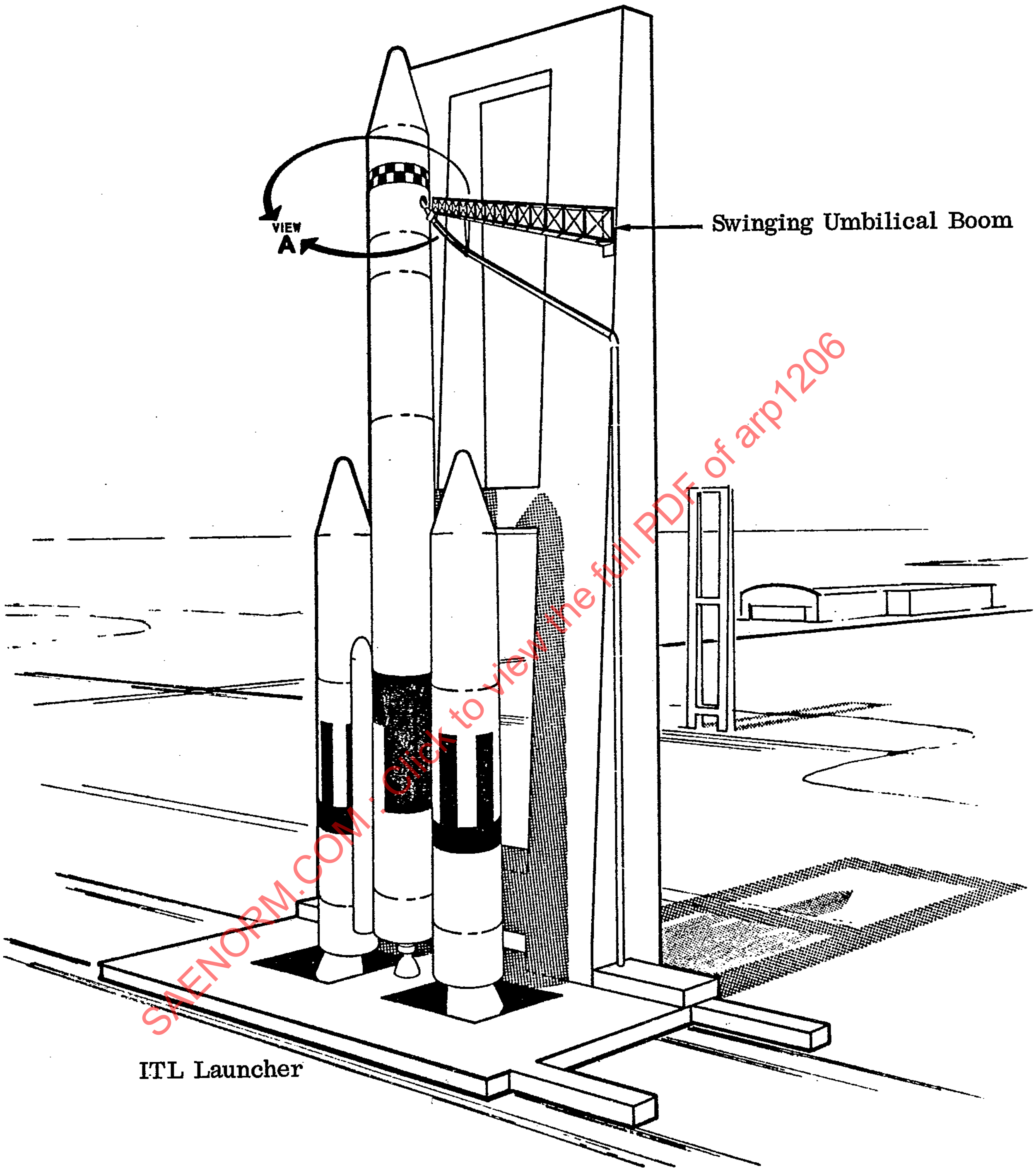

FIGURE 1 - SYSTEM REQUIREMENTS

VEHICLE UPPER STAGE FUELING

4. MATERIALS SELECTION

Because of the high reactivity of some fluids, materials must be selected with more than average caution. Added to this is the requirement to maintain structural properties at extreme temperatures. Many of the reactive-resistant metals and alloys retain toughness at the extreme temperatures for use with contemporary fluids.

To be avoided are porous metals where reactive impurities may be absorbed by the fluid. Troubles in service have generated from materials that contain impurities, and from systems that allow heat of reaction to accumulate up to the kindling point of a basic material. Corrosion problems in storing and handling some fluids occur, especially those with the more electronegative elements.

5. HAZARDS AND SAFETY

Although some fluids possess a high degree of reactive elements and react with materials, it has been found in many instances the fluids can be used if proper precautions are taken. Other considerations in the use of materials should include fluid compatability with respect to welding processes, vapor entrapment, etc. In view of the literature on these fluids and compounds, the facts must be considered in proper perspective. Due to the hazards involved with use of some fluids and compounds, the temptation exists to apply panic psychology to design and operating plans. However, there are many substantiated records of quantities having been produced and utilized by government agencies and industry, without serious injuries directly attributable to the use of the fluids and compounds.

6. DESIGN CONFIGURATION

The remotely activated quick-disconnect system is to be designed and fabricated to provide for remotely actuated and positioned quick-disconnect couplings used with liquid and gaseous mixtures. These couplings are intended to connect an Aerospace Ground Equipment propellant servicing system to an upper-stage vehicle for the purpose of loading or unloading fluids.

Although this ARP specifically emphasizes a remotely activated quick-disconnect coupling, design personnel must constantly relate to subsystems in the propellant servicing operations. A basic system for remote actuation of a coupling generally consists of three related subsystems. These subsystems are, in order of their importance: The quick-disconnect couplings (ground-half and air-half), the connector positioning and release mechanism, and the umbilical transfer line as shown in Figure 2.

The quick-disconnect couplings, consisting of a ground-half and an air-half, must have the capability of being mated and sealed when actuated by a remote connector positioning mechanism. The ground-half is to be mounted on the positioning mechanism and provide for appropriate alignment when mated with the air-half. The ground-half contains an interflow valve which is pneumatically operated to open or close on command.

Four methods of disengagement are provided. Redundant modes of disengagement are:

1. Manual
2. Electro-pneumatic
3. Lanyard/Boom movement
4. Emergency breakaway

Manual disengagement is provided for checkout and system varification prior to launch.

The primary operational mode is through actuation of an electropneumatic system, which is completely parallel in nature for optimum reliability. A remote generated signal, by dual paths, actuates parallel solenoid-driven valves mounted on the umbilical boom. These valves release an adjacent source of inert gas, through parallel piping, to positioning cylinders which perform the initial unlatching and withdrawal function.

In the event of failure of the parallel primary mode system, a flexible steel lanyard energized by an initial boom motion, performs the function of unlatching and disengaging the coupling.

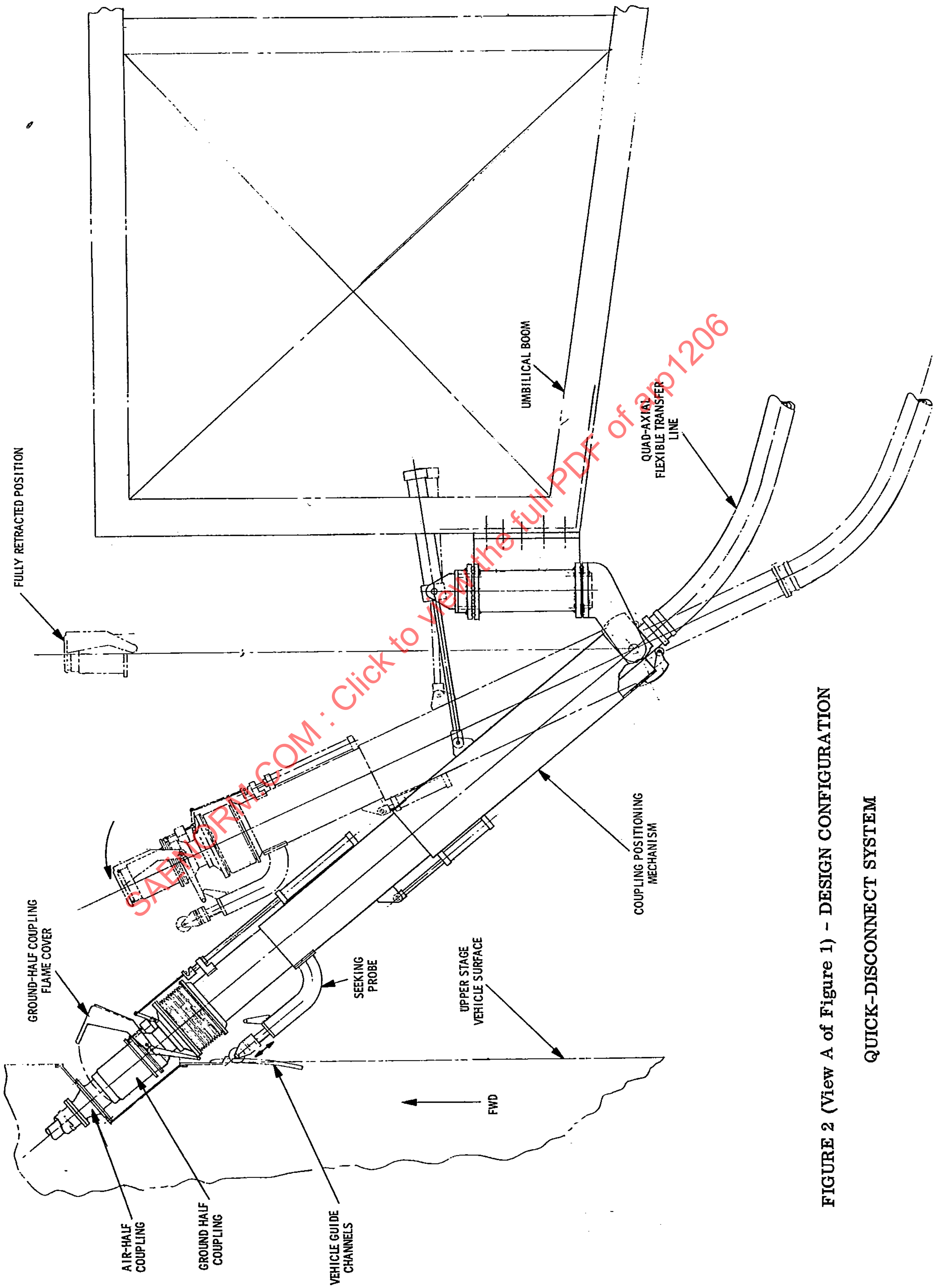

FIGURE 2 (View A of Figure 1) - DESIGN CONFIGURATION

QUICK-DISCONNECT SYSTEM

If all provisions of the redundant release system fail to function (including boom movement), vehicle lift-off motion shears a mechanical fuse - the ground-half latching pawls - thereby releasing the coupling and causing it to tilt toward the umbilical mast. This action provides a minimum six-foot clearance between the vehicle and ground-half of the coupling. The minimum clearance is infinitely more desirable than complete failure to release, which creates a catastrophic condition.

The air-half is mounted in a receptacle on the side of the vehicle with its longitudinal axis directed 45 degrees down from horizontal. The seeking probe of the ground-half locates and follows a delta-shaped guide channel to a stop pin. At this point the two halves, now linearly oriented, close, seal and latch. Remote indicator telltale lights reveal the system is safe for loading.

7. SYSTEM OPERATION

The ground-half coupling is designed to be compatible with requirements for the flexible metal connection of the umbilical transfer line.

The air-half contains a valve normally spring-loaded to the closed position. It is actuated to an open position by the ground-half interflow valve. The design is compatible to sealing-locking requirements of the ground-half coupling except where preempted by flight hardware requirements. The ground-half couplings are "form, fit and function" interchangeable, and capable of mating with any air-half without select fitting. A typical quick-disconnect coupling is illustrated in Figure 3.

The connector positioning mechanism is mounted on the umbilical boom including the ground-half. It positions, connects and disconnects couplings by pneumatically actuated remote control. The connector positioning mechanism is designed to permit free-floating action and displacement between the vehicle and umbilical boom. After couplings are mated and locked, it will be capable of compensating for an operational displacement equivalent to a 12 inch cube. The connector positioning mechanism will not transmit forces into the vehicle greater than 1500 pounds in any of three planes during connection, disconnection or a free-floating period.

Design of the fixed and flexible portions of the transfer line complies with applicable requirements of ASME Unfired Pressure Vessel Code, Section VIII, 1965 edition. Values of mechanical strength of materials are derated for the fluid line to account for possible corrosion in service.

The transfer line system includes a separate return purge line, when required, and is routed external to the main transfer line. This line, originating at the ground half, is designed to purge gases from the main transfer line and ground half. It terminates in fittings leading to a closed-loop propellant transfer system or selectively to a suitable disposal system.

Prior to roll-back of the mobile service tower, vehicle tanking and venting systems are connected semi-manually in conjunction with checkout and system verification tests.

The basic coupling is designed to serve as a vehicle tank vent coupling and fuel fill coupling, sized to serve the particular service.

At T-X seconds, a signal is generated to actuate the coupling disconnect and withdrawal system. The completed disconnect triggers another signal to the umbilical boom rotating mechanism, which swings the assembly back to the forward face of the umbilical tower. This entire sequence has been completed at approximately T-0 or first movement of the vehicle.

If a HOLD occurs during the terminal second countdown, it is possible to reconnect the coupling system to the vehicle - for an abort or for continuation of the topping-off cycle (replenishment). This type of reconnect operation is initiated at the propellant management and load console in the launch control center. The umbilical rotating unit causes the boom to move toward the vehicle. When positioned, the boom releases an interlock system, thereby permitting actuation of the umbilical coupling positioning mechanism. As previously described, the positioning mechanism extends the ground-half coupling to seek, mate, seal and latch to the air-half. When the latched condition is secured, another interlock system provides remote actuation of the coupling interflow valve for continuation of fill or drain.

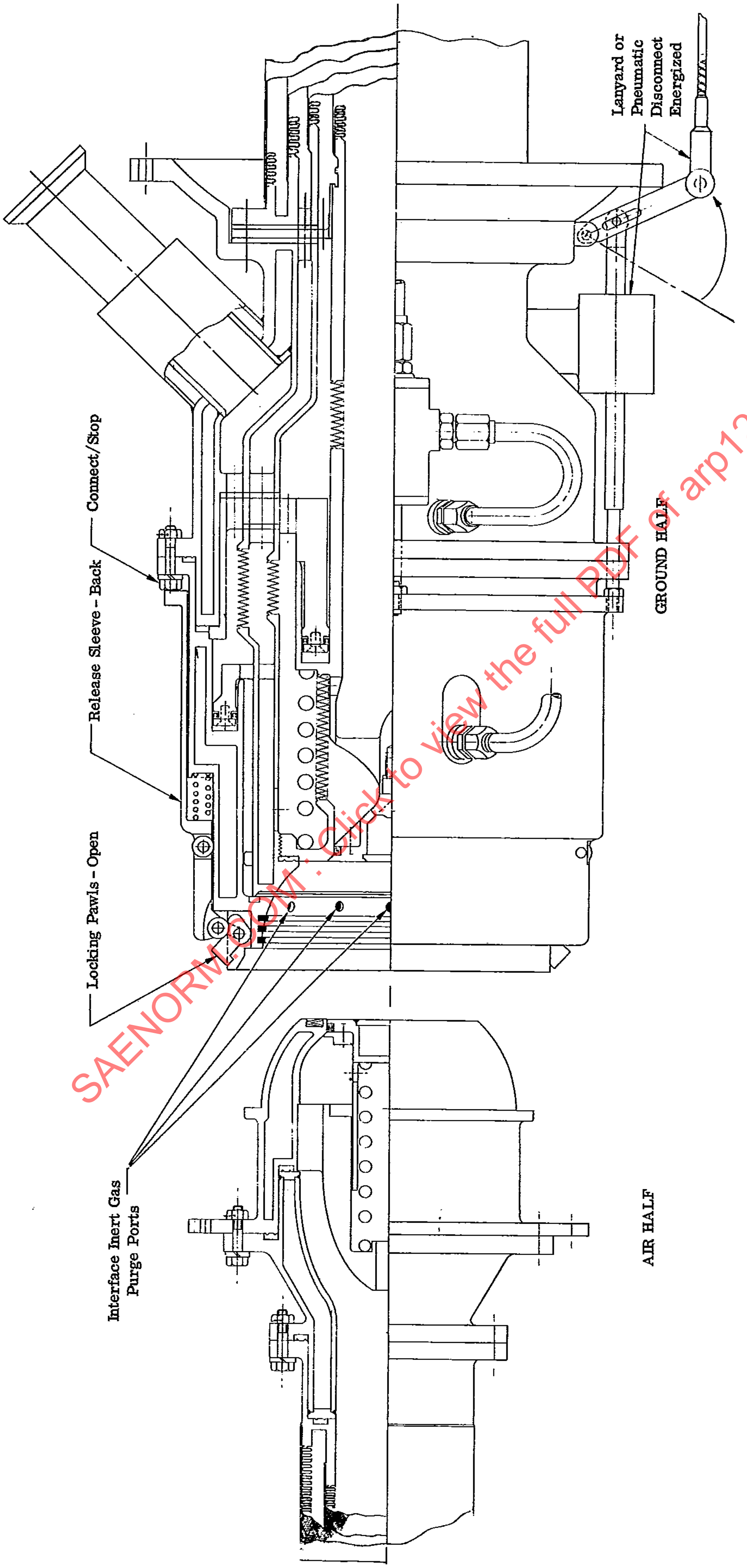

FIGURE 3 - SYSTEM OPERATION
QUICK-DISCONNECT COUPLING