CLEAN, DRY, OIL-FREE AIR

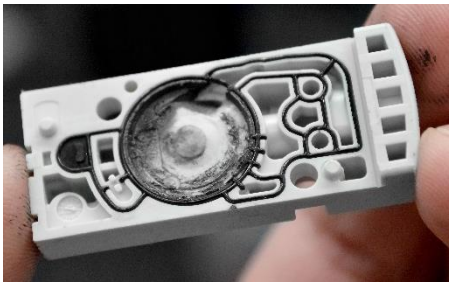
*The Key to Higher System **Repeatability** and **Service Life***

This application note is intended to provide system integrators, end customers, and their support staff with the knowledge and resources necessary to ensure they get the highest possible performance and longest possible service life from their **Soft Robotics** control system and tooling products. This note focuses on the role that air cleanliness plays in the premature failure of *electro-pneumatic* equipment and turn-key techniques for reducing the frequency of costly plant maintenance operations and the installation of spare componentry.

THE HIDDEN COST OF DIRTY AIR

Piloted spool and poppet valves can routinely operate well beyond 20 million actuation cycles when supplied properly conditioned air. Yet, determining the correct air cleanliness classification for your equipment and designing a practical facility air system which achieves it can be a difficult balancing act between compromised service life and excessively expensive air preparation options.

Failure to provide clean, dry, oil-free air can not only chronically shorten the life of integrated pneumatic valves to well below their nominal cycle life, but can also, in cases of severe contamination, cause intermittent and inexplicable valve failures only minutes or hours after installation. Once airline equipment and piping becomes contaminated with built up grime or corrosion, it is extremely difficult to clean often leaving no viable alternative to complete replacement.



A spool valve pilot manifold heavily contaminated with abrasive particles

HOW IS AIR CLEANLINESS MEASURED?

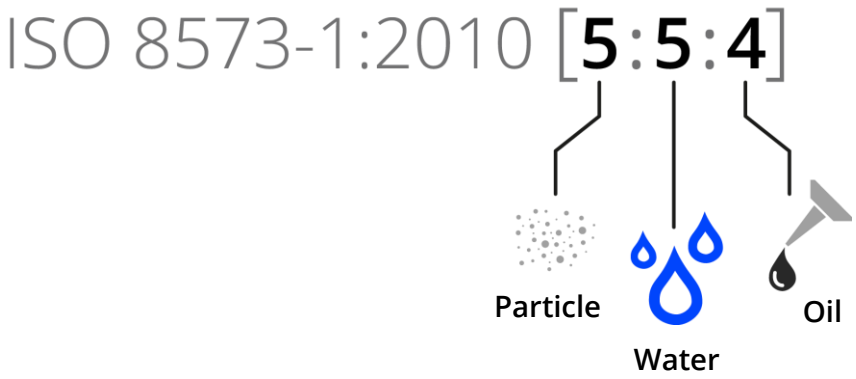
Air quality is typically assessed by defining the permissible contents of three principle contaminants: **particles** (dust or granular material suspended in the air stream), **moisture** (vapor, water mist, or liquid condensate), and **oil** (lubricant intentionally added to the airstream as an aerosol, or greases and oils which have crept into the system from air handling equipment by advancing along tube walls or vaporizing into the air stream).

Generally, moisture is the most difficult to remove without the help of equipment specially designed to dry air. Compressor aftercoolers, liquid separators, refrigerated air dryers, desiccant dryers, or membrane dryers are usually deployed sequentially or in combination to protect equipment with differing pressure dewpoint requirements throughout the facility.

CONTACT **solutions**@softroboticsinc.com
(617) 391-0612 / **www.softroboticsinc.com**

SOFT ROBOTICS AIR QUALITY RECOMMENDATIONS

Soft Robotics uses the **ISO 8573-1:2010** standard to specify our air purity and dryness recommendations. For all our control and tooling products, **a purity classification of [5:5:4] or lower is recommended**. This classification is typical of modestly sensitive applications like: general facility shop air, air tool supply, and sand blasting. The following section will detail the ISO 8573-1 standard's specifications for each contaminant type under this combined classification.



PARTICLE CLASS 5 REQUIREMENTS

Particle content is defined in the standard as a permissible number of particles per cubic meter of compressed air. Class 5 particle purity is the highest (weakest) classification which uses this measure of particle content, and specifies that fewer than 100,000 particles must be present between 1 µm and 5 µm in diameter per cubic meter of compressed air and **no particles larger than 5 µm in diameter**.

MOISTURE CLASS 5 REQUIREMENTS

Moisture or liquid water content is defined via two classification tiers. Classes 7 and above permit a specified amount of liquid water whereas classes 6 and below permit no liquid water to be present (as condensate or mist) and specify moisture content as a pressure *dewpoint* that may not be exceeded. Class 5 water purity classification requires **a *pressure dewpoint* lower than 7 °C (45 °F)**.

OIL CLASS 4 REQUIREMENTS

Oil content is defined as a permissible number of mg of oil per cubic meter of compressed air. Class 4 oil purity is the highest (weakest) classification and requires fewer than 5 mg of oil to be present per cubic meter. Oil may be present below this limit as a liquid, aerosol, or vapor but measurement of vapor content is optional when confirming compliance with class 4. **Generally, oil content will meet this requirement if not intentionally introduced into the system**.

ISO Standards **8573-2**, **8573-3**, and **8573-4** describe in further detail the test methods used to determine whether a compressed air sample complies with particle, moisture, and oil content classification [5:5:4].

CONTACT solutions@softroboticsinc.com
(617) 391-0612 / www.softroboticsinc.com

COMPONENT SELECTION FOR ENDPOINT PROTECTION

While the ISO 8573-1 standard provides highly precise metrics and measurement techniques for assessing air purity, it offers no guidance on the practical application of any combination of classifications. This section will focus on selecting commonly available components which can be used to meet or exceed Soft Robotics' air quality recommendations.

PARTICLE FILTRATION

Particle content and most liquid water or oil can be easily removed using a general-purpose particle filter. These filters typically use a cylindrical non-woven fabric filter element to reject particles larger than 5 µm in diameter, sufficient to meet our class 5 particle purity recommendation. The filter element is usually placed within a "bowl" into which supplied air flows through a spiral shaped vane. This creates a vortex within the bowl which centrifugally separates liquid water condensate and liquid oil from the air stream and collects it at the bottom of the bowl where it can be extracted through a drain.

The compact AW series filter/regulator by SMC

Even if similar filtration equipment is present elsewhere in the facility, **it's strongly advised to place an additional filtration unit near the final point of use**. This provides an additional layer of "last mile" protection should thread tape, dust, metal slivers, or other contaminates be introduced into the piping during maintenance or expansion of the facility air system.

All Soft Robotics control equipment requires a stable regulated supply of air pressure. Both pressure regulation and filtration can be performed in a single combined package. As an example, Soft Robotics recommends the **AW series filter/regulator by SMC.** This series integrates a high flow, manually-adjustable, relieving pressure regulator and a 5 µm particle filter into a convenient and highly compact package. When supplying air to a single control system, the AW30 body size is usually sufficient. If multiple control systems or other process equipment will be supplied air by the same filter/regulator, the AW40 body size is recommended.

MOISTURE AND OIL REMOVAL

In the most typical case, moisture and oil are removed at a central location within the facility near the air compressor. At class 4, Soft Robotics' oil content requirements can easily be achieved by placing a liquid separator directly at the compressor output. Liquid separators are similar in functionality to the particle filters described in the previous sub-section but usually do not contain a filter element, which mitigates pressure drop across the separator. Unless intentionally introduced by an aerosolizing lubricator, the primary source of oil and grease within the air system will be the compressor itself.

The most efficient way to achieve a *pressure dewpoint* lower than 7 °C (45 °F) is to integrate a refrigerated air dryer into the facility air system downstream of the compressor, liquid separator, and main *air receiver*. Refrigerated dryers are highly reliable and require minimal maintenance even under continuous use. By using a refrigeration circuit, pressurized air is rapidly cooled to ~35-40 °F which becomes the *pressure dewpoint* as water vapor saturates and condenses out of the air stream. It's always recommended that the final *pressure dewpoint* be at least 20 °F lower than the minimum facility ambient temperature.

CONTACT **solutions**@softroboticsinc.com
(617) 391-0612 / **www.softroboticsinc.com**

CONCLUSION

No single reference air system design can provide an optimal balance between quality, throughput, and cost for every facility. However, Soft Robotics control systems and tooling products have modest general purpose air purity requirements. We have specified these requirements and methods for their measurement by leveraging the ISO 8573-1 standard's combined air purity classification of [5:5:4]. **Typically, if your facility's central compressed air system has already integrated a refrigerated air dryer and liquid separator, no additional air drying or oil removal airline equipment is needed at the point of use**.

Some facilities have exceptional or extraordinary requirements which call for special care to be taken when ensuring that air is sufficiently conditioned for use. Some common examples include facilities where:

- Air purity requirements differ dramatically throughout various stations and process equipment
- Abnormal contamination hazards are present on an intermittent or regular basis (high concentrations of airborne particles, large amounts of water, or cleaning chemicals and detergents)
- Operations are conducted under widely varying environmental conditions which are not within those described in IEC 60068-1 (15-35 °C temperature, 86-106 kPa air pressure, and 25-75% relative humidity)

If any of these describe your facility, please consult Soft Robotics directly for further recommendations.

KEY TERMS

Electro-Pneumatic	An electro-pneumatic component or system uses a combination of sensors and electrically or pneumatically driven actuators to perform some function (e.g. directional flow control, closed loop control or sensing of pressure, proportional flow control).
Pressure Dewpoint	Is the temperature at or below which water vapor will begin to condense into a liquid in a gas sample pressurized to some reference application pressure (e.g. 90 psig)
Air Receiver	A tank coded and designed to retain pressurized air often used in one of two configurations: "wet" or "dry." A "wet" tank is installed prior to any air preparation equipment and is used to reduce compressor cycling and to vertically separate contaminates commonly discharged by the compressor (liquid oil, grease or grime, and liquid water). A "dry" tank is usually installed after all air preparation equipment and helps to level varying air consumption load from the application.

Soft Robotics, Inc.
32 Crosby Drive
Bedford, MA 01730

CONTACT solutions@softroboticsinc.com
(617) 391-0612 / www.softroboticsinc.com