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Specialty devices in engineered systems

In the integrated building environmental system, all major subsystems contain, in addition to the fundamental components, a number of devices, generally with moving parts, called specialty devices. The fundamental components are considered those that theoretically would function as a workable system under ideal conditions with steady-state capacity requirements. Examples of fundamental components are:

- *Refrigeration system* (vapor compression): evaporator, compressor, condenser, throttling device, and the three major piping segments.
- *Hydronic system:* source, load, circulator, compression chamber, and interconnecting piping.
- *Steam system:* source (generator), load (condenser), steam piping, and return piping.

Identify subsystem components

Such a grouping of fundamental components can and should be identified for each major subsystem.

The specialty devices are all the other devices that, rightly or wrongly, are employed to make the system function. These devices fall into one or more of three categories:

- Safety devices or controls
- Devices necessary for normal operation
- Indicating or status information devices

The importance of understanding the significance of these devices cannot be overemphasized. The simplest of systems are those that contain *no* components in addition to the fundamental components. The addition of any of the specialty devices in the second category above adds a degree of complexity to the system. Furthermore, the addition of any specialty device, assuming it is absolutely necessary to the safe and proper operation of the system, is one more element to maintain and service throughout the life of the system. If it does not warrant such maintenance and service attention, it should not be employed!

Many of the devices in all three categories have been developed in reaction to problems encountered in system operations. In many cases, rather than "designing out" the need by improved systems designs, the design community turned to designing the systems around the available specialty devices, thereby promulgating both the need for and the dependence on such devices. This dependence has influenced both system designers and product designers more than has fundamental design philosophy.

Reliability is vital

In addition to the disadvantages of complexity and maintenance service burdens, another significant penalty for the excessive use of specialty devices is the introduction of unreliability. The vast majority of such devices contain moving parts. Whether these parts be bearing surfaces (rotational or sliding), metal flexing (bourdon tubes or expansion compensators), or elastomer diaphragms (pneumatic relays), they are subject to failure! Such devices therefore lessen the anticipated statistical reliability of the system. To add to the reliability problem, the designers of specialty devices have, in many cases, value engineered the devices to an extremely low level of reliability to gain a more favorable position in the competitive marketplace. The subsequent acceptance of such lower cost (less reliable) products by the consumer (the system designer) has forced the entire market in the direction of less costly, less reliable devices. We thus find ourselves in a situation wherein the state of the art in systems design is dependent on myriad devices that in many cases, because of competitive pressures, are not available in high quality or high reliability products—at any reasonable cost!

As a brief example, take the case of air elimination in hydronic systems. The *fundamental components* concept assumes that the only fluid in the system is water. In reality, the available water contains dissolved gases that release to the gaseous phase at elevated temperatures or reduced pressures. This "air," when separated, causes restrictions of liquid flow at high points in piping systems, as well as corrosion and other undesirable conditions. Designers have been provided total flexibility of piping system design by the availability of automatic air vents that have been employed at all geometric high points in the system, as well as at the points where the pipes must drop to avoid interferences. Such devices sometimes fail open, releasing water from the system, which results in vapor binding and subsequent circulation failure in the whole system. The total failure problem can be solved with another specialty device, the automatic (usually pressure-controlled) water makeup valve (or open connection pump). This device enables the system to continue operating even though the "vent" is malfunctioning. Inevitably, however, the resulting continuous makeup water, containing calcium that fouls the high-temperature heat exchange surfaces, causes extended shutdown for descaling.

The obvious solution is for the designer to design the system so that air can be eliminated from the geometric high points at the time of filling the system, and so that there are no other gas collection points. He must design a single, high-quality, reliable air separation and elimination system that is easily accessible for regular monitoring, maintenance, and service. Reduced to a single point or device, a high-quality device can be employed at any reasonable cost.

Numerous similar examples could be given. However, the system designer might consider the general rule that the system should contain as few specialty devices as absolutely necessary, and those that are employed should be the highest quality, most reliable devices available.