“Ideal” Manifolds… Not So Ideal?

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The Benjamin Conversion manifold, or as it is more popularly called, the dual valve manifold, was utilized for cave diving and other environments in which regulator redundancy was deemed beneficial throughout the late 1970s to the mid-1990s. This manifold was a vast improvement over the pre-existing manifolds of the day, as they allowed two independent regulator systems to be used on the same set of doubles. Thus, if a regulator failure occurred (either first or second stage), the diver still had a viable option for self-rescue from the cave. During this time, cave divers worried about a few possible failures that could still result in catastrophic gas loss from the primary gas supply. These included:

- Burst disk failure
- Sudden, massive failure of one of the cylinder neck o-rings which seals the manifold
- Loss of integrity of the manifold itself

These concerns lead to the development of the “Ideal” or isolation manifold, which allowed the two cylinders to be isolated from each other, maintaining at least part of the gas in the event of one of the failures listed above. It was considered a vast improvement, and very quickly replaced the use of the “unsafe” dual valve manifold. It is the primary manifold used today for all forms of technical open circuit diving. Yet, my opinion is this valve does not add safety, rather it significantly reduces it.

During the twenty or so years in which the dual valve manifold design was in use, there was only one recorded failure of the type listed above that occurred while diving. This event occurred during a cave dive while using a Sherwood manifold incorporating a metal-to-metal seal. Immediately prior to the dive, the double cylinders were accidentally knocked off the preparation platform. They fell about three feet to the ground, landing on the manifold. The manifold was closely examined prior to diving, but was not leaking, and the divers elected to dive. After the cylinder pressure had been reduced to about 1500 psi, the manifold catastrophically failed, and both divers exited successfully sharing gas from the remaining rig. It was suggested at the time that the fall caused a displacement cylinders relative to each other, which did not manifest itself until the pressure reduction allowed the metal-to-metal seal to shift and lose integrity.

In addition, in 30 years of accident data collection, there are two instances of in-water burst disk failure recorded. Both events occurred with cylinders that had been pressurized beyond the working pressure of the cylinders (in one case almost to the hydrostatic test pressure!), and occurred within minutes of the cylinders being placed in the water (prior to cave penetration, while in a safe environment). Also, in both instances, the burst disks had not been replaced in many years. It can be hypothesized that the old disks had metal fatigue from small flexing associated with repetitive filling and emptying over the years, and failed due to thermal shock when placed into relatively cold water after being sun warmed on the surface. Cave divers used to alleviate this risk by double disking or soldering the disks shut, but these are not recommended procedures. A far better practice is to replace all burst disks annually. As both of these incidents occurred at the surface, prior to beginning the dive, an isolation manifold would not have benefited the divers, since they would have called the dive anyway.

In contrast, since the isolation manifold was introduced in the early 1990's, there have been many, many incidents related to misuse of the manifold. Most of these have been rectified without harm to the divers involved, but all of them had the potential for very serious consequences. The types of problems associated with this design of manifold along with representative case histories include:

1. **The isolation valve being closed prior to the dive.**

    Case #1: This involved a cave diver who began the dive with 3,000 psi (200 bar) in his doubles. He and his buddy did a S-drill prior to descending, indicating that both regulators were working fine. About 15 minutes into the dive, he noted that the pressure on his SPG was not dropping as expected. He reached up, opened the isolation manifold, and watched as his pressure dropped from 2,700 psi (180 bar) to 1,700 psi (110 bar). He called the dive, and exited the cave with no further incidents.

    What happened was that the diver was in the practice of always leaving his isolation manifold open. However, when he had it filled, apparently the fill station operator closed it. Thus, only one cylinder was being utilized during the dive. The diver using the cylinders did not check the isolation valve, since it was "always" open. The pressure drop seen was due to the S-drill usage, BC and drysuit inflation, and cylinder cooling after being placed into the water.

2. **The isolation valve being closed during filling of the cylinders.**

    Case #2: A cave diver planned a nitrox dive to a depth of 110 ffw. Prior to the dive he analyzed his cylinders and found that he had EAN32, as expected. He proceeded to a depth of 50 ffw, whereupon he began to experience symptoms of CNS oxygen toxicity. He immediately began sharing gas from his buddy, and aborted the dive.

    After examining the cylinders on the surface, the team found EAN32 in one cylinder, and 100% oxygen in the second. Apparently, at some time during the blending process, the isolation valve was shut, resulting in only one cylinder being properly prepared. This was the cylinder that was analyzed, and so everything appeared normal prior to the dive. At no time prior to the dive did the diver check the isolation valve.

3. **Roll off of the left manifold valve.**

    Case #3: A cave diver swimming through a tight cave passage experienced a sudden failure of his gas supply. He switched regulators, and aborted the dive. After surfacing, he found that left manifold valve was closed. It had been open prior to the dive, as evidenced by his utilization of that regulator for the entire period up to the sudden supply failure. His forward movement through the overhead environment resulted in the "auto-shutdown" of the valve, as the hand wheel turned shut off as it scraped across the ceiling.

These failures are only representative of those in the files, and related to me anecdotally from other sources. Cases like this are very numerous, and any of them could have resulted in a fatality. In my opinion, it is only a matter of time until one does.

One might argue that these incidents did not need to occur, and that it was the divers' fault for not checking the isolation valve prior to their dives. I do not disagree with this. However, when a piece of equipment opens itself up to a multitude of cases of "pilot error," while not providing any concrete improvement in other areas of safety, then the net result is one of additional risk with a commensurate reduction in safety. For this reason, and the history of misuse of the manifolds in the field, my belief is that we should go back to using the standard dual valve manifold of the 1980's or adopt another type of technology.

NOTE: This is one of a series of articles planned for *Underwater Speleology*, *NACD News*, and other journals of interest to the technical diving community which will discuss findings from the combined accident analysis files collected by the cave diving community.

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Jeff was certified as a NAUI Instructor in 1978, and for the NSS-CDS in 1983. He is certified to teach diving for the NSS-CDS, IANTD, TDI, and NAUI. Jeff is active in teaching cave, rebreather, nitrox, technical nitrox, and trimix diving courses. Together with his wife, Rebekah, he has maintained the combined accident files for the cave diving community (a joint project of the NSS-CDS, NACD, and IUCRR). He has published extensively on diving education topics, with heavy emphasis on cave diving safety techniques. He has edited/reviewed many diving textbooks, and is the author of Mastering Rebreathers. He has served on several Boards of Directors in the diving community, including as Chairman of the NSS-CDS and as Vice Chairman of NAUI, and as Treasurer on the AAUS Board. Jeff has received the NAUI Outstanding and Continuing Service Awards; the Silver Wakulla, Abe Davis, Henry Nicholson, and International Safe Cave Diving Awards; the SSI Platinum Pro 5000 Award, and is a NAUI Hall of Honor inductee.