It’s common to lose the vacuum shield and expose the N2 dewar to room temps. It’ll boil off slowly filling pit design or low room from the floor up.

If you want to be super safe put one O2 monitor up in the ceiling space (e.g. to activate emergency fans) for helium, and one at chest level to detect N2.

Make sure you get one of the long life (10yr) sensor units (e.g. PureAire) or you’ll be up at 2am every 1.5yrs with false alarms.

I wouldn't assume that just because you've got high ceilings, that you're fine - do the calculations for a) the volume of the room and b) the maximum amount of gas that can be boiled off from all the magnets in the room. It's true that in a quench you're not *likely* to evaporate off all of your cryogens, but you have to assume a worst case for the calculations. In places that have had a quench, while it looks like the helium has all risen to the ceiling, actually there is significant gas mixing and the "clear" air in the middle is also significantly depleted in oxygen. So for calculations we assume perfect mixing.

Going from 20ish% O2 in regular air to 18% is enough for the onset of symptoms of hypoxia, and that only requires you to fill the room with 5 vol. % of a gas that we can’t breathe (i.e. nitrogen and helium). This is a lot less than you think it is!

We have fixed oxygen sensors in sensors in all of our magnet rooms at both floor and ceiling height, and we also have portable monitors that act as backup in case we have power outages.

Things that can cause a quench include (unknown) manufacturing defects and/or bad luck (so unpredictable), and people doing stupid things like driving cylinders past the magnets. Contractors are a particular issue since they tend to have a very laissez-faire attitude towards safety and large metal objects - there was an incident at UNM where some welding tanks got sucked off of a contractors back and quenched the magnet (http://nmr.unm.edu/magnet.html).

Given the real risk of asphyxiation and death we have a real duty of care to our users so I wouldn't take this lightly!

I have an O2 level meter in my main lab, but it is a mixed blessing. My lab is also big and spacious, with good air handling.

I have had a 600MHz magnet quench, and stood by the meter to see if it changed readings, and it did not. The magnet was in the farthest corner of the lab, and I could see the cold vapor being drawn across the ceiling and out.

Ever 18 months to 2 years or so the sensor will need to be replaced. You could do this on a regular schedule to avoid bad readings, but the lifetime is somewhat variable.

So you get a situation where you either close the lab according to the reading, or you need another sensor to reassure users. I have a portable sensor for this purpose. A Honeywell BW Clip O2, which is disposable and has a two year life.

Here at [REDACTED], we have oxygen sensors in all NMR/MRI rooms. It is mandatory. Better be safe than sorry...

If you have a quench, both helium and nitrogen will escape.

This can happen during helium and nitrogen fills if not done properly.

It can also happen if you have a subcooled magnet and something goes wrong with the pump system.

The quench will happen if you do not do the He/N2 fills on time or if you have ice formation in your magnet.

Hope this help.

For what it's worth, I've been through the same discussions here. We also have high ceilings (16', with another 4' of space above that with ductwork). The Bruker site planning guide suggests to have an O2 sensor mounted near the ceiling and another near the floor. We decided to not mount one near the ceiling, for a couple of reasons:

1. There is risk involved for maintaining it (the sensor head needs to be changed every ~2 years, and someone needs to climb a tall ladder or use a lift to do so)

2. The only thing that would cause that to potentially go off would be a quench. If there were a quench and someone were in the room, they would have plenty of other indicators before the sensor tripped (particularly the noise of a quench). If it happened when nobody is around, the helium would be long gone by the time anyone arrived. I'll point out that the room has about 4 air changes per hour, and even very cold He gas is still much less dense than RT air so it goes immediately to the ceiling and beyond. We also have no building floors above us.

We did decide to keep sensors mounted near floor level (one near each spectrometer). We use N2 for the pneumatics (including lift/flush/VT gases) and, as you pointed out, if there were an event that caused large amount of N2 gas to fill into the room you could get a low oxygen environment. Almost all of the pneumatic connections in the console and downstream are these push-in Legris fittings with PE or PU hoses, and if one of those failed you could have N2 accumulating. For us, the spectrometers are near the corners of the room, where the air changes might be a little less than the whole room, so the sensors would provide an early warning if there was an issue.

The only (and very important!) position an oxygen meter should be mounted is at slightly above floor level: this is where cold nitrogen gas will accumulate and where someone who fell will be lying!

No point installing a „quench detector“ (near the ceiling) - if your lab has a smoke detector then you already have one and a quench is typically harmless because you see exactly where the helium level starts (cloud layer) and gravity won’t pull you to the ceiling… ;-)

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our EHS required that we cover both – a sensor at 8 ft for helium and a sensor at 2 ft for nitrogen

Purchased these:

https://www.pureairemonitoring.com/all-categories-gas-monitorsair-check-o2-oxygen-deficiency-monitor-for-co2-n2-storage-areas/

We have O2 sensors and an emergency vent system. During a planned quench I watched the cloud layer formed by the helium slowly come down from the ceiling and then go up again as the vents did their work. This was while standing in the doorway holding a portable O2 sensor. I only did it, because, the magnet expert Bert Heise, was standing next to me and told me what would happen. The O2 level barely moved from normal.

I can only imagine a sudden loss of nitrogen if the container fails e.g. when using a really high pressure nitrogen dewar to fill it?

We would fill our magnet weekly. The NMR was in a small room with a high ceiling. If we did not open the double doors to the room during the N2 fill, our O2 detector would go off during the fill.

Also, you need two O2 detectors. One near the celling for the escape of He and one about 18 inches off the ground for N2.

Concerning the question of O2 detectors, we are considering here in France at least two issues:

_ the law (security and sanitary rules)

_ the operation hazards.

Concerning this second point, I see mainly two cases of nitrogen flood in a lab:

_ failure of a nitrogen tank while filling the spectrometers (quite rare)

_ a gas leak in a nitrogen tank if the tank is stored in the lab, and the ventilation is not wonderful (I already worked in an NMR lab without installed ventilation...).

In case of, you could also consider the cas of a 200 mBar B50 nitrogen gas bottle stored in the lab having a leak (for example, a backup bottle for a cryo-probe).

My opinion: I do not consider nitrogen as a real big concern. Indeed usually rooms are big enough to "dilute" the nitrogen gas. In case of an NMR magnet quench, only the helium is vaporizing, not the nitrogen (even during a provoked quench by breaking the vacuum).

Our EH&S wants O2 sensors in all our NMR labs. Here's when I 'expect' N2 levels to be high in the lab:

-During fills. If I'm doing one magnet at a time and I have enough air exchange, it's not even close to a problem. But multiple magnets at a time in a smaller space is definitely a concern. We have a lab with an N2 probe. If we refill the probe dewar and the magnet at the same time, we can easily trigger the O2 sensor.

-Catastrophic failure of an N2 tank. If your liquid N2 tank is stored in the magnet room and fails catastrophically, it could displace enough O2.

-Quench. I know of a case where there was an outside-in type quench. During an N2 fill the transfer line had a tiny leak. Drops of N2 trickled down the outer can until they eventually froze the O-ring and the N2 boiled off rapidly, immediately followed by the He. I suspect that this could have potentially suffocated someone.

Things I would consider are:

Do you have a legal obligation to install them?

Can you get portable/wearable detectors for people in the lab during high risk operations - cryo fills?

Are you able to train all users to recognise a quench, and what to do when one happens?

The main events that have triggered the alarms in my lab are:

Oxygen level detection system fault.

N2 dewar vented in direction of detector

Filling 2 magnets simultaneously without leaving the door to the lab open.

Quench (one planned, one unplanned)

The last two items could have caused asphyxiation had the detection system not been in place Even with an alarm system you have to train all users what a quench is and what to do when it happens. It's the slow release of gas during an N2 fill that can be the biggest risk as there is only limited indication that it is there.

I'm afraid i don't have insights on what can cause N2 boil-off, but I have some other thoughts on O2 sensors. One thing you can look at is to ask your Facilities folks how many air exchanges the NMR room has per hour. Vendor should be able to tell you how many there should be for safety, in their Site Planning Guide. If you already have enough, or if they can bootstrap a system that will provide enough, maybe you won't need an O2 sensor; not sure on that, though.

We had a new building designed a few years back with benefit of Site Planning Guide. We have an O2 sensor in our NMR room which will trigger a supplementary fan system when it alarms. Problem with the system has been frequent false alarms (became as frequent as 12 times an

hour when a sensor failed). I despise our system for this reason; the alarms are deafening, louder than sitting next to a Dewar when it vents. Every single alarm we've had has been a false alarm, and we've had dozens since we moved to the new building in 2018. I realize the sensor may be required for safety in the facility; I just hope you can find a reliable one.

I think you need these monitors. In a recent quench (during cryoshimming) we found that the quench process selectively condensed the oxygen from the room, so that the O2 level at floor height (significantly below the helium cloud) was significantly reduced (not to zero, but below 15%) for about 10 minutes.

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we only have oxygen sensors in our labs that have undergone any type of renovation. We do not have to install them in previously existing labs. This is our EHS / code rule at our institution (older labs have grandfather clause). I hope this helps,