



# Chamber Cleaning Gases

**David Cooper, Global NF<sub>3</sub> and Fluorine Product Manager**

*Welcome to another podcast from Air Products, I'm Ed McKendry and today we're speaking with Dave Cooper. Dave is the global NF<sub>3</sub> and Fluorine product manager for Air Products. And our topic is Chamber Cleaning for thin-film photovoltaic applications. Specifically, we're going to talk about recent developments in on-site supply of chamber cleaning gases that Air Products is bringing to the market.*

*Why is Air Products pursuing the concept of on-site production for supply of chamber cleaning gases?*

Air Products has long history of on-site supply of molecules, beginning all the way back with our founder, Leonard Pool, and his pioneering concept of introducing and installing small oxygen plants at customer's sites as far back as the 1940's. But really, the biggest drivers to on-site supply of chamber cleaning gas to the thin-film/PV market are economics and reliability of supply.

The tools used in next-generation silicon thin-film photovoltaic facilities will require substantially larger quantities of chamber cleaning gases. Whereas a state-of-the-art 300mm semiconductor manufacturing facility might require 60,000 – 100,000kg per year of NF<sub>3</sub>, it is estimated that a 1GW thin-film PV facility will consume approximately 1,000,000 kg per year of NF<sub>3</sub>... a 10-fold increase in demand, per facility. Clearly, there are economies of scale driven by such high demand for these materials, and Air Products feels it can offer an on-site solution to not only provide for the most cost-effective supply, but also for the most reliably supply.

*You mentioned NF<sub>3</sub> when you spoke about the chamber cleaning gas requirement... Is NF<sub>3</sub> the only solution?*

Well, traditionally, the semiconductor and flat-panel display industries have standardized on nitrogen trifluoride (NF<sub>3</sub>) as the optimal gas for their chamber cleaning requirements – and, indications are that NF<sub>3</sub> will remain the chamber cleaning gas-of-choice for the PV industry for the foreseeable future – however, there is interest in the potential for using elemental fluorine as a chamber cleaning gas alternative.

*So, is Air Products continuing to focus exclusively on NF<sub>3</sub> for the silicon thin-film PV market?*

Not at all... Air Products has a full range of offerings. First and foremost, we have a demonstrated, cost-effective, and market leading NF<sub>3</sub> ISO container supply chain. With more NF<sub>3</sub> capacity, and substantially more dedicated ISO containers than any of our competitors, we've been meeting our global customer demand for NF<sub>3</sub> for over 30 years. Recently, we've developed low-cost, on-site chamber cleaning gas supply options for the PV market for **both** NF<sub>3</sub> and fluorine. Both of these designs leverage our industry leading experience gained from operating large-scale NF<sub>3</sub> and large-scale fluorine plants for over 35 years, and both platforms will meet all applicable standards of safety, reliability, and cost-of-ownership.

*Talk about safety? Isn't there more of a risk associated with fluorine than NF<sub>3</sub>?*

Yes, there is. A very serious consideration for any customer, and for Air Products, must be safety. At Air Products, we pride ourselves on our position that nothing is more important than safety, and we've designed that into our on-site offerings.

While potentially offering cost-of-ownership benefits at the substantially higher consumption levels associated with large PV plants, elemental fluorine may pose significantly higher safety risks than  $\text{NF}_3$ .

- Fluorine is a powerfully reactive element, and it requires specific knowledge in system design, operation, and maintenance
- Fluorine compression, required for on-site supply, is dangerous
- Personnel exposure and emergency response concerns need to be addressed
- And, perhaps most important, anhydrous hydrogen fluoride (HF), one of the raw materials required in large quantities to support on-site fluorine production, is among the most dangerous and toxic of materials used in the electronics industry.

*You're describing a pretty scary situation here, why would anyone take the risk with this material?*

Perhaps better than anyone, Air Products understands these risks. Really, as the only supplier with proven experience in the design, construction, and operation of large  $\text{NF}_3$  as well as large fluorine plants, Air Products has a great deal of experience in designing for these safety considerations – and, a long history of safe fluorine operations. We've got four large-scale  $\text{NF}_3$  plants and five large-scale fluorine plants in operation around the world, and we've taken the safety learnings and system improvements gained over decades of operational experience and incorporated them into our on-site offerings.

*Which supply mode is best for PV customers? ISO containers? On-site production of  $\text{NF}_3$ ? On-Site production of fluorine?*

The answer to that question really depends upon several factors, including:

- A customer's specific volume requirement over the project life
- The required product purity
- Reliability, up-time, and back-up requirements
- Local energy costs, raw material sourcing, local infrastructure
- There are others I'm probably forgetting...

*Any parting comments?*

Just this... Air Products stands ready to assist PV customers in the selection of the optimal supply mode of chamber cleaning gas to their facility. We feel our safety culture and history, our on-site supply expertise, our 35 years of operating history, and our global operations and project execution infrastructure position us best to provide fluorine or  $\text{NF}_3$  to our customers at the lowest cost-of-ownership. Air Products also has an array of chamber cleaning process experts and atmospheric scientists who are available to help overcome any process issues or concerns. I would tell anyone with any questions to contact your local Air Products account manager or visit our website to get more detailed information specifically tailored to your particular situation. Thanks for your time.

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