Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL) Thule Projects

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I have been working on Thule projects since 2009. Since that time we have designed and build several large buildings at Thule, to include: dormitories, CE Shops and Vehicle Maintenance facilities, power plant upgrades. In the process of designing in the arctic, on permafrost, we had to consider many scenarios that are typically taken for granted. Those include considerations for foundations, heating and cooling, thermal-bridging, quality of building air tightness. Some of the examples of foundation considerations included:

- **Building on permafrost elevated building** – the challenge with such buildings is to assure that there is adequate separation below the buildings and the ground as well as enough insulation (in the ground and at the building) so that the heat does not penetrate the soil and melt the permafrost. We have built several 3 story dormitories utilizing this method, it is the most common at Thule.
- **Excavating to bedrock with slab on grade foundations** – one of the most reliable methods of constructing in the arctic is to excavate all of the ice reach material to competent bedrock and backfill with Non-Frost Susceptible (NFS) material. The challenge of this technique is that the bedrock is not always shallow enough where excavation is economical. In our designs for large industrial facilities we were fortunate that bedrock was shallow enough where we could take advantage of this method. However, in an open excavation speed and adequate compaction is critical so that the sun does not melt surrounding ground and create ponding or unstable ground. NYD was able to build 2 new large facilities utilizing over excavation,
- **Pile foundations** – a lot of discussions have taken place regarding this method. While it can provide for relatively fast and cost effective installation the challenge and the risk comes once the building is complete. Namely, the ice rich material surrounding the piles may melt and depending on the pile depth, or whether its an end bearing pile the surrounding soil may make the entire building unstable due to lateral forces. Of course the lateral motion could be accounted for however, the construction cost is magnified so that it no longer becomes cost effective. To this day there are no building that we are aware of that are built on piles.
- **Slab on grade with foundation coolers/Thermo-siphons** – this method is one of the original used at the base, where the cool air circulates under the slab in the winter to keep the soil stable. In our designs we have met with varied reactions given the mixed success of such design. It requires quite an effort to assure the foundations are performing as designed. It requires attention and inspections each season. Given that most of the slab on grade original buildings at Thule have cooled foundations and that most of them have foundations cracking it was not a favorite design option. Thermo siphons have been considered, however the potential maintenance in case leaks would be cost prohibitive. Also those require attention each season.

Heating and cooling the considerations included oversized preheat coil, tremendous loads for large air circulations, especially for areas where heat recovery is not feasible. The challenge we have faced was when we designed a paint booth for vehicle facility. To make it more challenging the operation of the

paint booth typically is in the coldest part of the year. The heat demand for proper circulation required us to install an auxiliary heat exchanger on the steam system to keep with the demand.

One of the bigger issues we have faced in our experience is with building envelope and thermal bridging. The contractor has learned this lesson early on in our experience at Thule. While our drawings and discussion with the contractor emphasized the importance of properly installed envelope the quality of the build has proven to be not adequate. It resulted in multiple alarms being set off on the heating system as well as frozen sanitary line. It was uncovered that with only several small unfilled cracks in the insulation and lack of insulation on the foundation columns the building kept on freezing. Once the issues has been rectified no further issues have been identified. Another instance of thermal bridging that we faced was on the exhaust vents of the dryers. Tenants would complain that once their clothes were dry they would find them half frozen if not removed promptly. The solution was to use UV resistant pipes, non-conductive and non-metallic with dampers and insulation extending several feet in the building. Another method of combating thermal-bridging was thru use of plastic separators especially on arctic hood mounts and external roof supports for stacks. This has prevented the occurrence of icicles and moisture buildup within facilities.

With experience and lessons learned, sometimes the hard way, the quality of the construction at Thule has improved, where the contractors understand the importance of having sealed building and properly prepared foundation. Both the contractors and designers appreciate the collaboration received from CRREL, (Kevin Bjella and Jim Buska (retired)), without their expertise and input the road to success would be long and hard.