Dehumidification Options

Steve Krstulovich, Mike May, Ray Stefanski

Tunnel Moisture Load:

The cost of dehumidification is directly related to the moisture the tunnel air will pick up from water sources in the tunnel. To keep the air dry at low cost, it will be essential that water sources are eliminated or kept to a minimum. Areas where tunnel walls show excessive infiltration should be sealed if possible. Water should not be allowed to pool or run through open trenches - drainage should be provided in a closed piping system.

The 35km tunnel is approx. 6 times the size of the current Main Ring tunnel. A recent study of dehumidification issues in the Main Ring showed that humidity comes from 3 principle sources besides the ventilation air intake. These are:

1. Transmission through concrete = 5 lb/hr
2. Trench and sump evaporation = 170 lb/hr
3. Allowance for water spray from leaks = 70 lb/hr

which gives a figure for moisture build-up in the Main Ring of 245 lb/hr. If we multiply this by the factor of 6 increase in tunnel length for the 3 TeV machine we would have over 1000 lb/hr in moisture released to the tunnel air.

This straight forward scaling does not directly apply, because water spray from leaks should not be an issue as only cryogens are anticipated in the tunnel. However, trench and sump evaporation, if multiplied by a factor of 6, would result in 1000 lbs/hr release to the air. Because the dolomite is not a good water conductor at a depth of 400 feet, we can be optimistic about controlling water penetration through the tunnel rock, especially if care is taken to seal the bad spots. Trench and sump evaporation can be improved by use of enclosed drain lines and sealed sumps.

With these considerations in mind, we would design a basic dehumidification system to handle 200 lbs/hr, with provision for expansion if conditions prove more extreme in reality.

Ventilation System Capacity:

The ventilation system shown in figure 1 allows for the minimum breathing requirements for tunnel personnel. Air is introduced into the tunnel at one of the two access shafts, and released at the other, the two halves of the ring being fed in parallel. The system shown has a capacity of about 15,000cfm which results in a 100fpm wind (1mph) through the tunnel and a 1"wc differential pressure end to end. This minimal ventilation reduces moisture load from outside air intake to a minimum, however, it also results in a 10 hour air purge time for the tunnel. The cost for this scale of system (not including tunnel ducting) would be about $700K[1]. It would have the ability to remove 200 lb/hr of tunnel moisture (in

---

[1]

150 ton air cooled chiller (1 ea)	$100K
15,000 cfm air handler with run around coils (1 ea)	$30K
15,000 cfm exhaust fan (1 ea)	$5K
250 gpm glycol pumps - chiller & run around (4 ea)	$20K
DDC controls and interlocks allowance	$50K
Piping and accessories allowance	$60K
Electrical allowance	$30K
Ductwork to and from shafts allowance	$40K
Equipment pads and supports allowance	$5K
TOTAL CONSTRUCTION COST W/ OH&P	$390K (w/o tunnel ductwork)

addition to outside air moisture) to keep the tunnel moisture below the dew point at 55F. The ventilation unit will have to be fitted with heating capacity for winter operation.

The ventilation system could be increased to allow for additional capacity. For every 1 lb/hr of tunnel moisture, 75cfm of additional air flow would be needed, at a unit cost of about $3.5K (not including tunnel ductwork). At a size of 150,000cfm (allowing the tunnel to be purged in 1 hour) the ventilation system would be able to remove 1800 lb/hr of moisture and with economies of scale would cost about $5M (not including tunnel ductwork). Air velocities in the tunnel would be about 1000fpm (10 mph) and require a differential pressure of 8”wc across the tunnel, which would require special design considerations.

Auxiliary Dehumidifiers:

Auxiliary tunnel dehumidification units could be placed down the tunnel length. At a half mile spacing between units, 44 units would be required. To preclude dead spots in the tunnel air movement, due to these units simply recirculating on themselves, it would probably be necessary to run the ventilation system concurrently. These units normally range from 10 lb/hr (size 300 unit) to 32 lb/hr (size 1200 unit) moisture removal capacity each. This would total 440 to 1408 lb/hr capacity for 44 units. The unit cost of this type of equipment runs about $2.5K per lb/hr capacity (not including electrical installation and assuming that no ducting is necessary). An example of a ventilation unit mounted in a 10 foot tunnel is shown in figure 2.

Other Considerations

The 3 TeV accelerator adds about 3 watts per meter in heating to the tunnel. This represents about a 100 kwatt heating load. This would increase the tunnel air temperature by about 20 degrees F at the exhaust point. This actually serves to help the dehumidification system in the following sense: In the Winter, the chiller system is turned off and the outside air is heated before injection into the tunnel. The extra heating from the accelerator components helps this process.

An Electron Ring

An electron ring will loose energy in the tunnel due to synchrotron radiation at a rate that may be as high as 50 Mwatts. Such a high heating load could not be air cooled, and would have to revert to another cooling medium - presumably water. The addition of a large water cooling capability into the tunnel could complicate the dehumidification problem, because of the potential for leaks. Recall that the Main Ring must allow for as much as a 70 lb/hr load that could come from leaky water systems.

Conclusions

A ventilation system for a 3 TeV ring need not be an excessive cost to the project. A great deal depends on the care taken to seal potential water sources in the tunnel. Based on the experience gained at the Main Ring tunnel, a system that can handle a 200 lb/hr load could very well be sufficient.

However, the 200 lb/hr system should be treated somewhat optimistically as a target. As more data become available, and plans for the electron machine firm up, the dehumidification requirements can be predicted with greater certainty.

EDIA allowance (15%)	$60K
Management Reserve allowance (25%)	$115K
G&A allowance (23%)	$130K
TOTAL PROJECT COST (w/o escalation)	$695K (say $0.7M)