# Quality Improvements at Virginia Transformer Corporation

**By Parminder Panesar**

## 1. VPD – Vapor Phase Drying Process at VTC

**Why VPD**

In power transformers, reliability after the robust design and flawless execution is the insulation system. The cellulose based insulating boards and papers have been used in transformers for > 100 yrs. These usually contain 8 - 10 % moisture (H2 O) by weight at 23 deg C and normal RH.

This moisture reduces the dielectric breakdown strength in kV/ mm, resistivity is also lower. In the presence of voltage field, the moisture will result in partial discharging measures in Micro volts. These will rapidly reduce the dielectric strength, leading to premature failure of the transformer. When the moisture content is less than 1%, the normal life of insulation system per IEEE std is 20 years. However, with the superior processing at VTC and GTC to achieve 0.5 % moisture, the transformers life is increased to 60 years. While the phenomenon of life reduction due to high moisture is more pronounced in voltages 69 kV and higher, the rate of progression is somewhat lower in 5 and 15 kV transformers. Therefore, it is utmost important to remove moisture from insulation to maintain its insulating properties at the highest level to achieve longest possible life. Conventional oven drying can achieve 1 to 1.5 % moisture, vacuum oven drying can achieve 1 %. For lower moisture levels it is essential to use a process called Vapor phase Drying (VPD). The cost of VPD systems runs > $ 1.5 million. The equipment maintenance is very high, processing time is up to a week, and the energy consumption is as high as 10X of conventional drying. It is a sophisticated piece of equipment involving physics, thermal science and high precision process control.

**Operating Principle.**

Vapor Phase Drying (VPD) applies vacuum, spraying with vapor of water absorbing liquid and removing the moisture in the form of condensate from the liquid. In this method the carrier of heat is a vapor of a low viscosity solvent like kerosene but with a higher flash point. Kerosene is heated in an evaporator/ heat exchanger by use of electric or gas heaters by heat exchanging with a higher temperature thermal fluid. Solvent vapors formed are sprayed over the core and coil assembly then placed inside the Autoclave for drying. The solvent vapor condenses when encountering the lower temperature transformer core and coil assembly. The condensed kerosene carrying moisture from the insulation is circulated through a condensate coil and is continuously evaporated and condensed. the water collected is weighed and the process is continued till the moisture level reaches the desired % of weight of the total insulation.



VPD plant at VTC plants , Roanoke [Picture 1 and 2]

**Moisture level of the Dried insulation:**

The mositure level of the dried insulation is measured in the completed transformer before shipment. Dry air or Nitrogen is filled in the tank. the mositure in the insulation equiliberates with the moisture in the gas over a period of 24 hours. The dew point of the gas rises due to taking moisture from the insulaion. The reulsting Dew point of the gas is measured using a Vaisala or similar equipment. The insulation moisture level is calcualted by the dew point and the temperature at which it is measured. At 0.5% insulation moisture level the Dew point must not be higher than -40 deg C at 23 deg C . At VTC and GTC plants achieve dew points of -50 deg C.

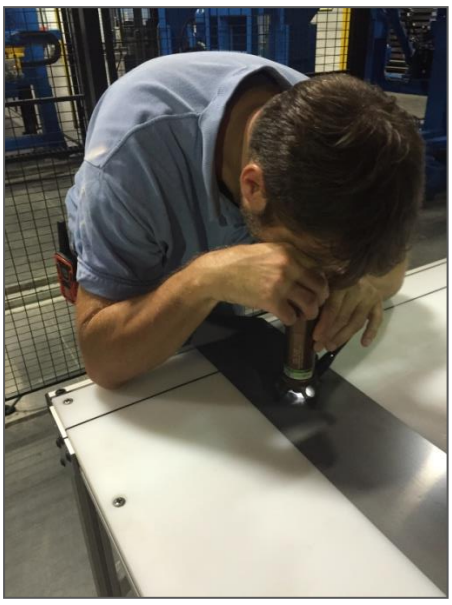
## 2. LASER burr measurement for Core steel

**Why Burrs are important for reliable transformer.**

- Burrs and slivers of steel are left on the edges of the electrical core steel lamination which occur during the slitting and shearing processes. Laminations used in transformer cores are between .007" to .013" (177 to 330 microns).
- These affect the transformer operation in several ways. 1) the adjacent laminations' burrs allow eddy current circulation and sparks due to emf between the laminations producing additional core losses and potential decomposition of oil in the vicinity of the sparks. 2) the burrs freely vibrate at 120 Hz producing sound and vibration in the transformer. The sound level can increase by 2 to 5 dB. 3) the burrs break off and are carried by oil circulation, they can lodge in electrical fields and cause dielectric failure. A high level of burrs will increase the cost of operation. Generate combustible gas in the oil, and the potential of catastrophic failure.
- Therefore, the burr on core steel lamination should be eliminated or kept to a minimum. Typical industry standard for burrs is .001 In (25 microns). VTC and GTC plants monitor burrs during the cutting process, change / adjust the blades as needed to maintain control. Burrs as low as .0003 In (8 microns) can be achieved with the use of laser measurement and superior machine maintenance and better than 1-micron finish on the shear blades.

**Burr measurement at VTC GTC plants.**

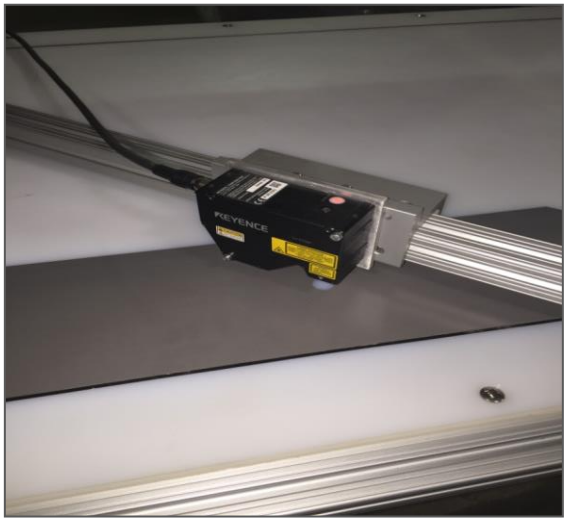
In the past the burrs were measured using micrometers. These typically bent the raised burr being very delicate and gave lower than actual burr height. In the 90's the optical micrometers were introduced, this was a huge improvement.

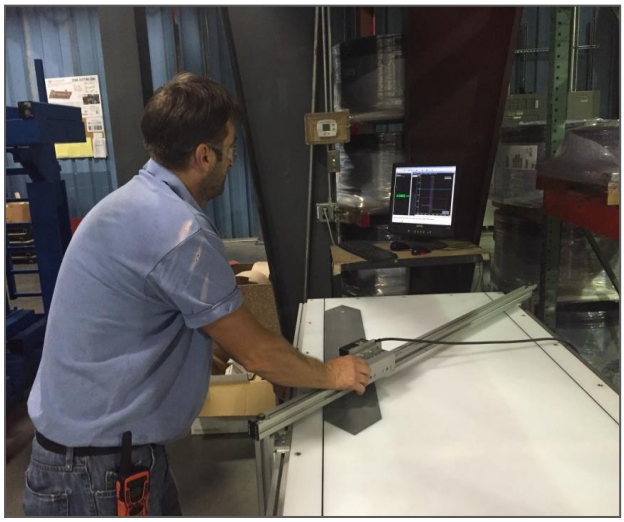


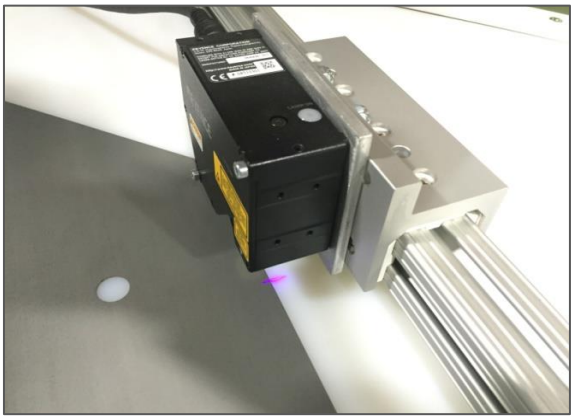
Limitations of optical micrometers

- Operator (Technician) has to calibrate the instrument for every measurement.
- Instrument has at least a count of 0.5 mil (13 micros).
- Readings often vary from operator to operator as it is dependent on the how the operators read; in other words, not reliable.

- New Method of burr measurement – <u>using LASER instrument.</u>






Advantages

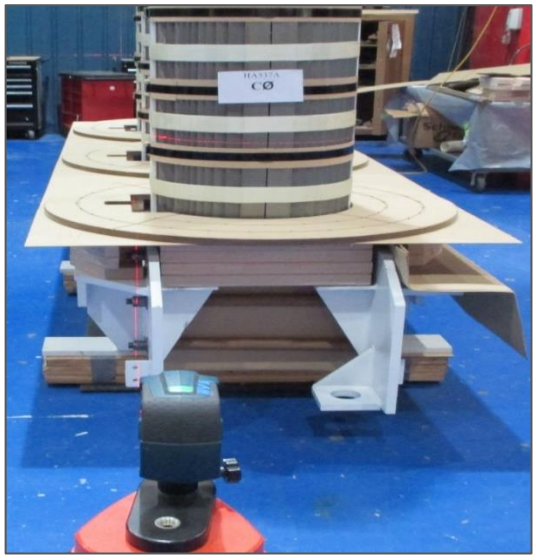
- No calibration required for every measurement
- Accurate automatic measurement – no human intervention involved in measurement
- Instrument provides least count to 0.1 mil (2.5 microns)
- The burr data is saved in excel format; reports can be saved per job for records. Reports can also be used to track burr preventive actions prompting preventive maintenance with respect to blade change with accrued data.

## 3. Checking of dimensions by LASER in C&C assembly, assembly check, verticality

Keeping the core and coil assembly plumb in the tank will maintain the designed clearances to the tank wall. The lead clearances can be verified to design. This improves quality and reduces cost by not overdesigning clearances. An additional benefit is a reduction in manufacturing time.

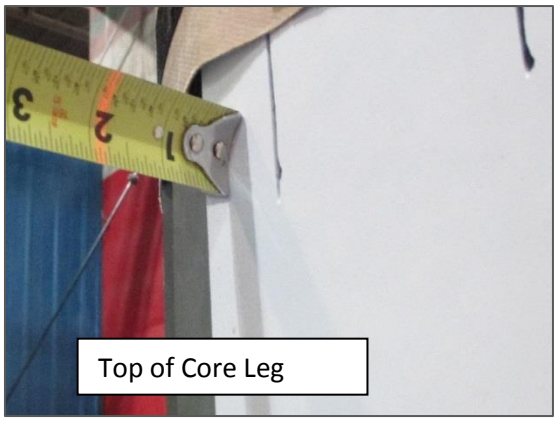
- To verify core straightness and verticality, the assembly group uses LASER level tools. This method is used to check and verify core level and legs verticality in front view and side view.

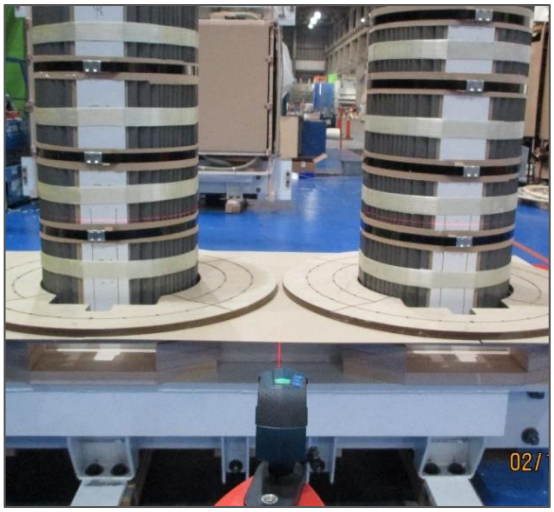
- Set Laser level on side of unit and adjust so that laser is approximately 1”-2” away from core leg. Reference picture below.



Setting up LASER in side view

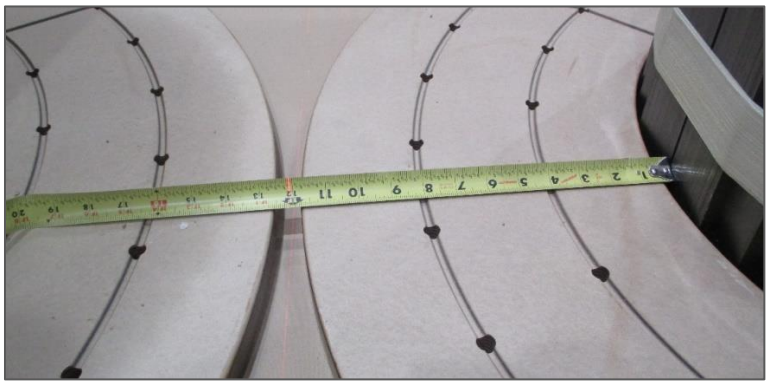
- Using the Measuring tape, take measurements at the bottom and the top of the core leg. Reference pictures below.

Setting up LASER Front view

Set Laser level on side of unit. Adjust laser to the center of the core leg window



Using the Measuring tape, take measurements at the bottom and the top of the core leg in the core window.

These methods are employed to check manufacturing tolerances; if these tolerances are not met, then engineering and Quality is to be consulted before proceeding.

## 4. Robotic welding for tank fabrication

Welding is a process where two materials are fused together by melting, intermixing, and then cooling the materials and/or a filler to form a strong joint. The weld is typically stronger than the parent material. From arc welding to spot welding, welding robots are typically used in the welding process where the weld required is repetitive. The robot travers speed is consistent without stops. quality and speed are crucial for reliability and cost. Robotic welding is an automated process in 6 Axis that increases efficiency, consistency, and Quality. With the exception of some hard to reach places, 90% of welding can be done by robot at VTC tank fabrication shops.

Use of Robotic welding has provided many advantages which include:

- Consistent cycle times
- Better weld Quality
- Better Throughput
- Improved safety
- Conservation of materials and consumables.

Robotic welding at VTCR

Robotic Welding at VTCU

At VTC Roanoke – A 6 Axis Fanuc welding robot is used to weld tank seams and other joints to provide excellent weld quality. Currently VTC, Roanoke is looking for a vision system to incorporate top cover parts welding and radiator valve welding.

At VTC Chihuahua – A 6 Axis Crane Suspended Welding Robot is used to provide great weld quality on weld seams and other critical joints.

## 5. Automatic paint mixing system

Second only to the quality of the core and coil inside the tank, the paint is important for long uninterrupted service of a transformer. After sand blasting to remove scale and provide a profile to capture the paint film, the actual application of paint spray is what determines the long rust-free service. Rust, looking ugly, also reduces the thickness of walls and reducing the mechanical safety margin. All the paint systems at VTC GTC are tested to pass the NEMA 3R outdoor exposure testing. Many of the processes are suitable for marine and chemical environments.

- Virginia Transformer uses two component-based primers and paint systems to provide a durable and pleasing paint finish to the product.
- In addition to temperature, a consistent mixing ratio, sweat time, and drying time are critical to the quality of a painted transformer. The automatic paint mixing system eliminates all these variables and provides better quality and efficient process.
- Eliminates operator errors delivering a perfect paint quality every time.
- Independent paint systems are installed at first coat and final paint booths.

Pros:

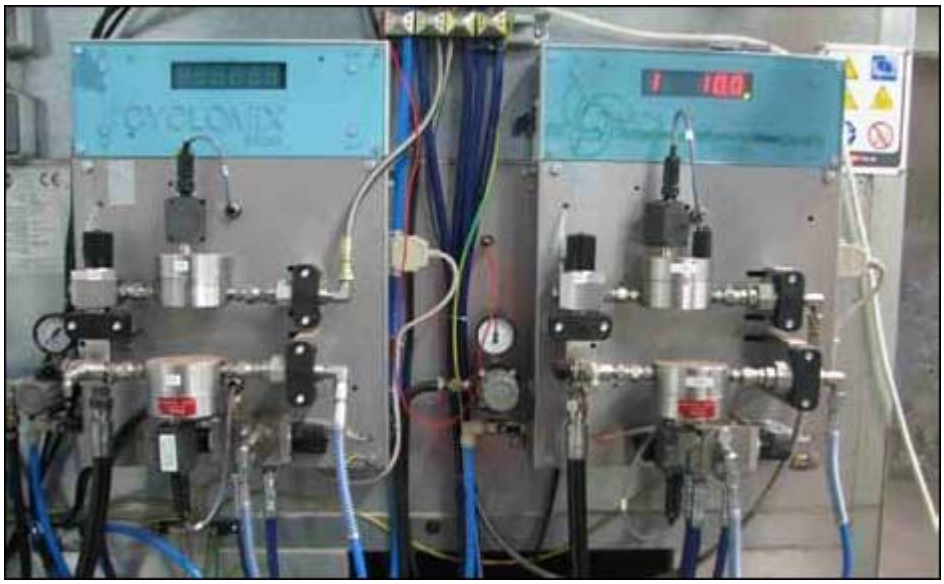
The paint systems used at VTC GTC draw paint components into a mixing and heating system.

The mixing:

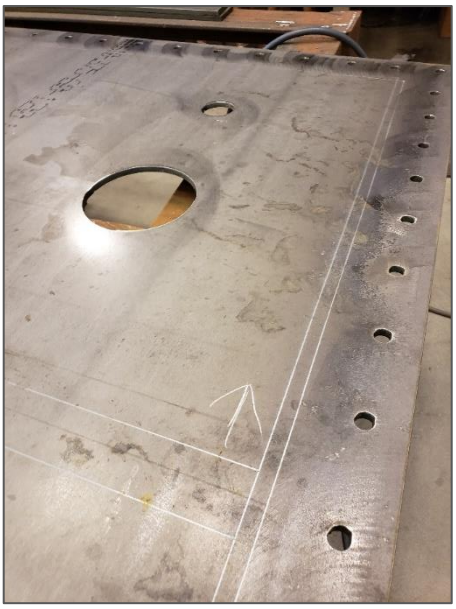
Reduce labor - Increase productivity

Consistent finish quality - Less rework cost

Reduced hazardous waste

## 6. Etching of parts location on tank steel using X Y coordinates from the CAD File



The location of parts used to be layed out by using tape and later laser measurements. This was time cosuming and prone to errors. The location of the part is 'etched 'on the steel plate with a tugsten carbide mounted to the X Y traveling arm. The arm is driven by a the DXF file from the 3D CAD design. The example shows Etched top cover for bracing location marked. The lines are produced by the scribing on the plate.

- Etching on sheet metal plate for location of weld parts accurately
- Reduction in time for operator to lay the part at location before welding
- Error Reduction: as coordinates coming directly from engineering CAD Drawings
- Improved efficiency and throughput