Set-up and Operation of “CIRC E-PIT probes™” for carburization detection:

The CIRC E-PIT™ probe is a single channel Absolute probe, as shown in Figure 1A. A photo of the CIRC E-PIT™ probe on a Ø4” (101.6mm) nominal, high chrome furnace tube sample is shown in Figure 1B.

Figure 2 shows sample data from a high chrome steel furnace tube (Ø4” 0.237” wall, 101.6mm x 6 mm wall) with internal carburization, together with instrument and gain settings, shown in Figure 3, to assist you with the CIRC E-PIT™ probe set up.

Procedure:

1. Follow the steps in the manual to start AdeptPro MC and connect to the Ferroscope.
2. Apply instrument settings as indicated in Figure 3.
3. Set gains as shown in Figure 3.
4. Set other routine tasks as outlined in the manual.
5. Do probe liftoff (LO) tests and record LO test data. LO tests can include front, back and whole probe LO.
6. Carry out the examination by recording data while rotating the probe around a tube.
7. For calibration, use two carburized tubes with different depths and rotate the “Y” signal to vertical. The Y-value or the amplitude value can be used to calibrate the data. Use the reading from the “cold” side of the furnace tube to represent 0% carburization.

As you can see from the attached data, the optimal instrument settings for this sample tube are:

f1: 15 Hz @ drive voltage = 5V  
f2: 30 Hz @ drive voltage = 2V  
Amplifier gain: 200 x 2 = 400

Note: Different tube material may have different optimal settings.

If you have difficulties with detecting flaws or obtaining a clean base line; try different frequencies; increase drive voltages or manual gain as high as possible without saturating the signals (saturated signals are shown by straight lines or the yellow triangle symbols on the chart recording display).
Figure 1A. CIRC E-PIT™ Coils layout

Figure 1B. CIRC E-PIT™ photo
Figure 2. Sample CIRC E-PIT™ circumferential scan data (Y-component) from tube 30% ID carburized on hot side
**Figure 3. CIRC E-PIT™ Instrument Settings**
This procedure will detect and quantify carburization of furnace tubes that starts on the inside of the tube. Carburization affects furnace tubes in a variety of process environments, and embrittles the tube over time, leading to eventual brittle failure.

The carburization process requires furnace temperatures generally above 800 degrees-C and a source of carbon. In the examples shown below, the tube was in a coker furnace service, with heavy oil flowing on the inside of the high-chrome tube, and a heat source (burning natural gas) on the outside of the tube.

In this example, the source of carbon is the heavy oil, which deposits a thin layer of coke on the hot side of the tube. The coke provides the carbon source which slowly permeates into the tube wall, making it harder and more brittle.

The reason that this remote-field method is so effective at detecting the depth of carburization is because carburization strongly affects the electromagnetic properties of the tube. One way to find the areas in a furnace that are more carburized that others is to use a regular E-PIT™, longitudinal scanning probe first, and then use the CIRC E-PIT™ to measure the maximum depth of carburization in those areas.

![Carburized case](image)

**Figure-4: example of ID carburized tube (Nital etched)**

**Note:** carburized material appears as a lighter colour
Figure-5 showing internal coke layer and 2mm deep ID carburized case
Note: carburized material is a lighter colour
Figure-6: 0.8mm ID carburized case thickness with very little internal coke
Note: Carburized material is a lighter colour
Figure-7: 2.0mm ID case depth with thick coke deposit and light ID pitting
Note: Carburized material is a lighter colour

Notes:
1. In all examples shown, the maximum carburization was on the hot side of the tube (closest or facing the gas burners).
2. Carburization can also start from the outside of the tube, acquiring its carbon from the combustion fuel. This process is typically slower and affects the cold side of the tube as well (i.e. the tube may be carburized at all points on the circumference, depending on the elevation of the tube in the furnace...which assumes that higher elevations are hotter).
3. The CIRC E-PIT probe is designed so that it can get very close to attachments such as hangars. This allows the operator to check if the attachment has acted as a concentrator to the heat, thereby locally overheating the tube and accelerating the carburization.
4. For *internal carburization*, phase can be used to predict case depth. In our example above, there is about 0.3 degrees of phase change for each 1% of case depth increase. However, for *external carburization*, phase cannot be used as there is no phase change for varying depths of carburization. In this case, Amplitude or Y-component can be used.
5. In both cases, calibration on samples of known carburization depths is essential.

![Figure-8: external carburization example. Note: Carburized material is a lighter colour](image)

Notes:

1) In the example of *external carburization* shown in Figure-8, note that the carburized material (lighter colour) is 100% through wall in the centre of the photo and decreases to 50% and then 30% as the distance from the hot side increases.
2) The 100% through-wall carburization was in an area where there was an attachment (hangar)
3) This type of localized, through-wall carburization has caused furnace tube failure and fires on unit start-up