Ground Penetrating Radar Technology and It’s Use in Delayed Coking Units

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Agenda

♦ Key Takeaways
♦ Explanation of GPR Technology
♦ Examples
♦ Limitations of GPR
♦ Onsite and Offsite Capabilities
Key Takeaways

◆ Safety is an important consideration when working around an operating delayed coking unit
◆ What is GPR?

What is GPR?

◆ Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface (ASTM D 6432)
◆ GPR uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum
Electromagnetic Spectrum

- Visible Light Spectrum
  - 400-790 THz = Wavelength of 390-750 nm
- GPR in 400-1600 MHz range
  - Wavelength around 90 to 30 cm (35-12 in)
- All light (in vacuum) travels at 299,792,458 m/s (6.706166E8 Mi/hr)
  - Less depending on the material

What is GPR? (cont.)

- GPR detects the reflected signals from subsurface structures
- GPR can be used in a variety of media, including concrete, rock, soil, ice, fresh water, pavements and structures
  - It can detect objects, changes in material, and voids & cracks
GPR Technology Limitations

- Limitations of GPR
  - Recent advances in GPR hardware and software have done much to address these disadvantages, and further improvement can be expected with ongoing development.

GPR Technology Limitations (cont.)

- “Truth and Verification” is always recommended for NDT (Semi-Destructive Testing - SDT) by excavating a series of exploratory windows into the surveyed reinforced concrete element.
- Correlation with additional NDT like Impact Echo Testing aids in validation of test results when SDT can’t be performed due to hazardous conditions.
Electromagnetic Energy

- Energy response dependent upon two material properties:
  1. Electrical Conductivity
     - Higher conductivity results in greater energy absorption and thus a weaker image

Electromagnetic Energy (cont.)

2. Dielectric Constant
   - Range from 1 (air) to 81 (water)
   - At 81, speed of light reduced to 1/9th original speed
   - Dielectric of concrete ranges from 3 to 12
Electromagnetic Energy (cont.)

- GPR hardware detects differences in dielectric/speed of light

  - Primary readings will occur with material changes – specifically at interfaces:
    - Concrete/Steel
    - Concrete/Air

GPR Device

- Windows OS CPU
- Antenna Receiver
- Wheeled Cart
GPR Device (cont.)

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GPR Device (cont.)

- Radar waves travel from GPR
- Radar waves impact steel at distance and reflect back to receiver
- GPR passes over steel, continuously taking readings
- Creates a data hyperbole at the location of the steel
- Dielectric contrast detected by GPR
GPR Device Imaging
Grain Silo Wall, Age: 40 years

GPR Device Imaging
Sulfur Pit – Good Condition, Age: 20 years
GPR Device Imaging
Sulfur Pit – Bad Condition, Age: 50 years

GPR Device Imaging
Sulfur Pit – Moderate Condition, Age: 10 years
GPR Testing/Survey Limitations

- **Metals**
  - Will obscure data below it (i.e., shadowing effect)
- **Fluids**
  - Will alter dielectric drastically
- **Coke residue on reinforced concrete boundary surfaces can affect readings**
  - Coke oil impregnates itself into the concrete matrix

GPR Testing/Survey Limitations (cont.)

- +/- ¼” Error (vertical/horizontal) typical on device
- Coke residue build-up can distort readings an additional ½”
- Delamination(s) can increase “Radar Signature Echoes” and further distort readings
- Cell phones, two-way radios, etc. adjacent to device will interfere with data collection
On-Site Capabilities

- Can detect an approximate thickness of a sulfur pit slab or wall
- Can determine rebar spacing, orientation, and approximate depth
- Can detect conduit, post tension cables, and subsurface piping

Begin by Grid Marking Survey Area

On-Site Capabilities

Grid can include Entire Surface or Representative Areas in Regions of Equipment or other Physical Obstructions
On-Site Capabilities

Wheeled Antenna Follows Grid Lines Collecting Data Continuously that Stores in the Data Acquisition Unit

Data is Acquired and Processed along Grid Lines Once the Antenna has Respectively Traversed at 90° Angles

On-Site Capabilities

Underground Utility And Void Check Prior to Crane Placement For Upcoming TAR
Off-Site Capabilities

◆ Can detect a more accurate Thickness of the Slab or Wall, with Composite Depth Contour Mapping
◆ Can determine Rebar Spacing, Orientation, and Approximately Mapped Locations onto CAD
◆ Can detect Conduit, Post Tension Cables, and Subsurface Piping and Approximately Mapped Locations onto CAD
◆ Can create 3-D, ‘Section Cut’ of Slab or Wall

GPR Survey Safety

◆ Preliminary scans performed from adjacent ground surface in voided regions
  • On-site verification of pavement slab thickness and/or void location
◆ Scaffolded installed over utility vault/pit roof slabs
  • Supported on pavement surrounding subsurface vaults/pits
  • Scans can be performed from scaffolding (with potential increased degree of error)
  • No additional loading to utility vault/pit roof slab other than GPR antenna
◆ GPR is battery-operated
  • Not an Intrinsically Safe Device (ISD)
  • Very low energy output – approx. 1% of ambient cell phone coverage waves
Sulfur Pit Inspection Scaffold Superstructure

Thank you!

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