



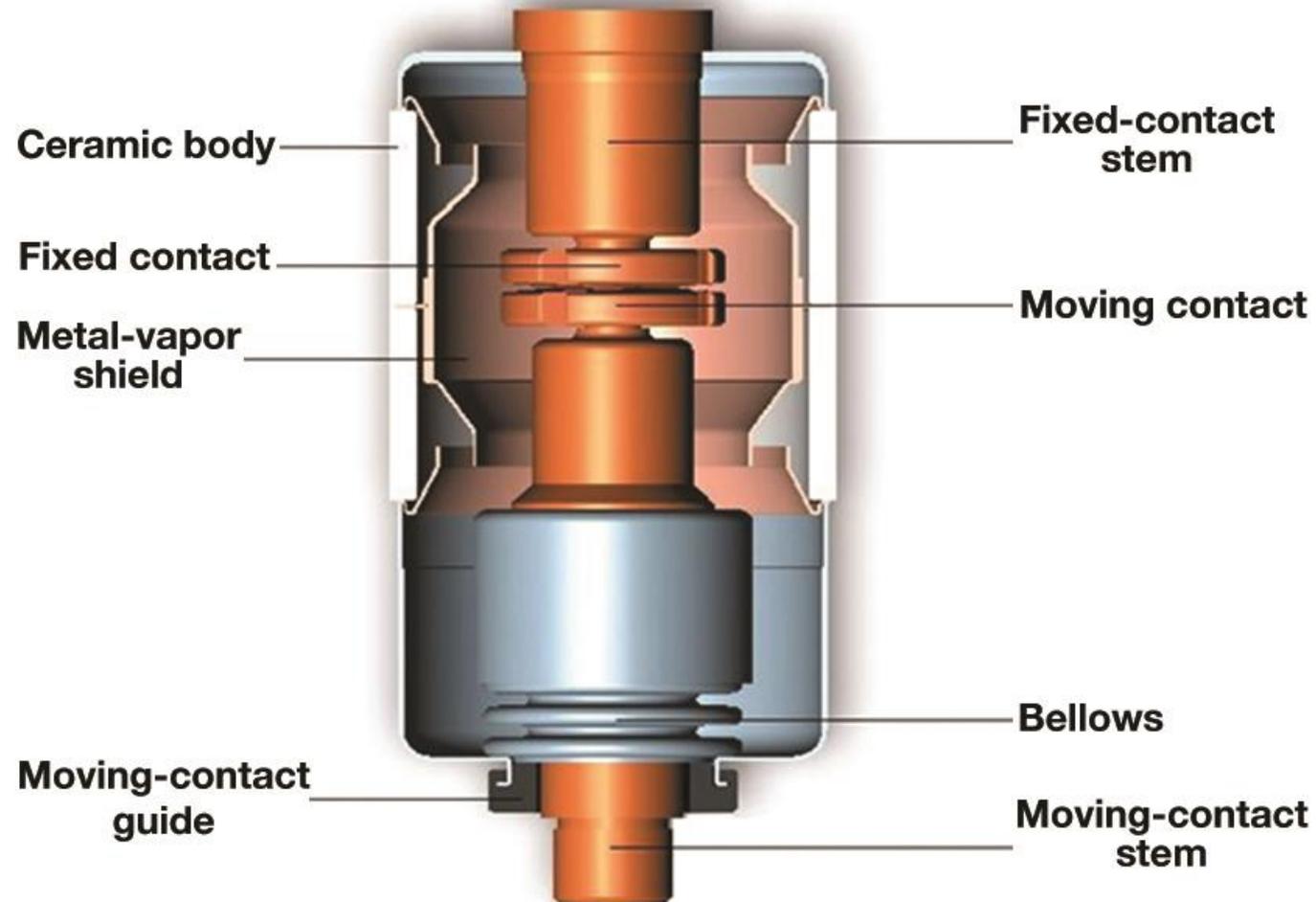
Vacuum Interrupter Field Tests Solve Mystery of Failing Breakers at Wind Farm

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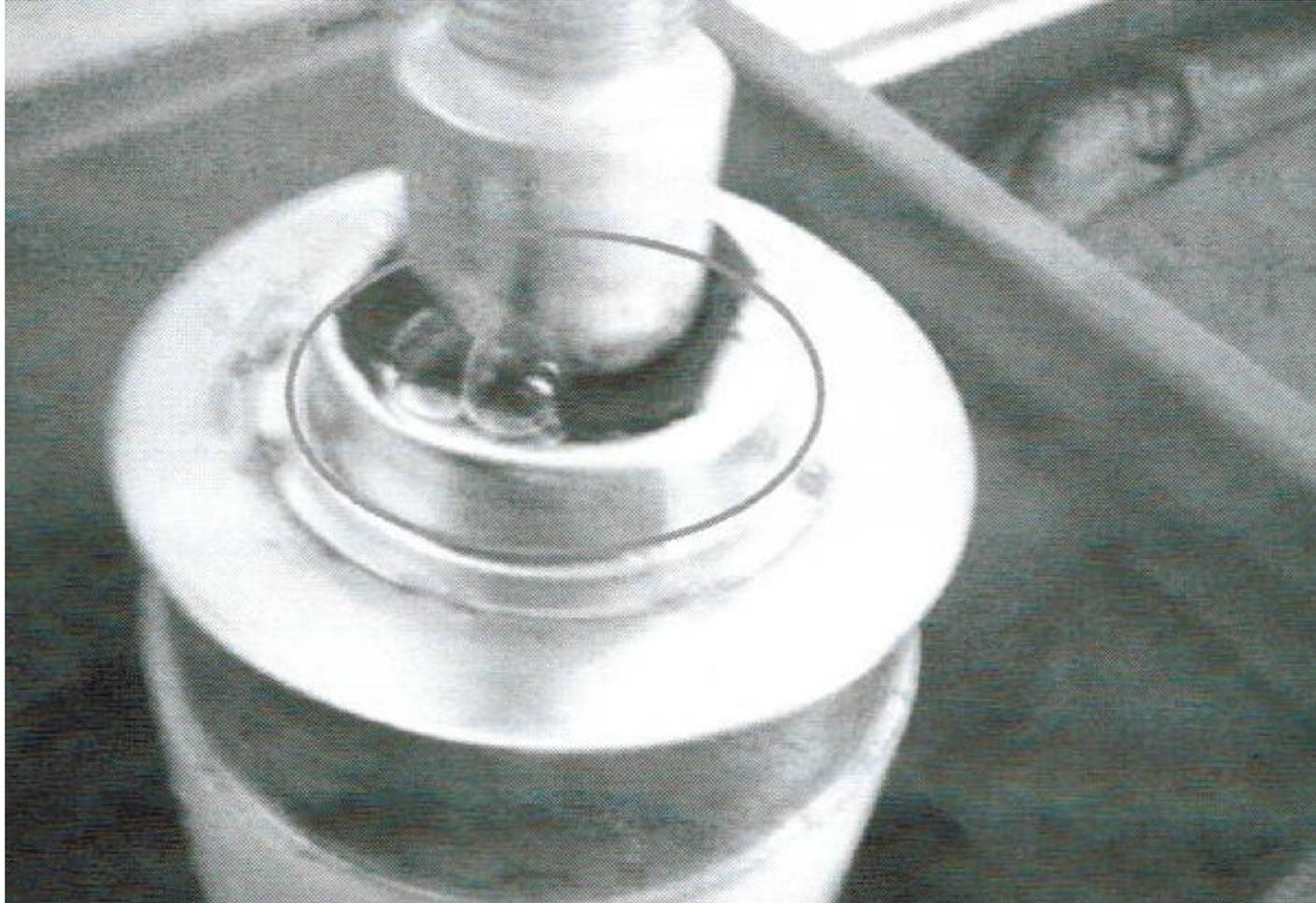
The Problem

- New medium voltage vacuum circuit breakers recently installed at a US wind farm were failing, and no one could figure out why.
- Engineers for the project contacted NETA-certified electrical field-testing and repair company Western Electrical Services, (WES, Sumner, WA). WES, part of Group CBS family of electrical companies, turned to Vacuum Interrupters, Inc.
- Based on magnetron atmospheric condition (MAC) testing, the TS-4 system identified five vacuum interrupters that had unacceptably high pressure inside the vacuum interrupter, indicating that the new interrupters were defective.

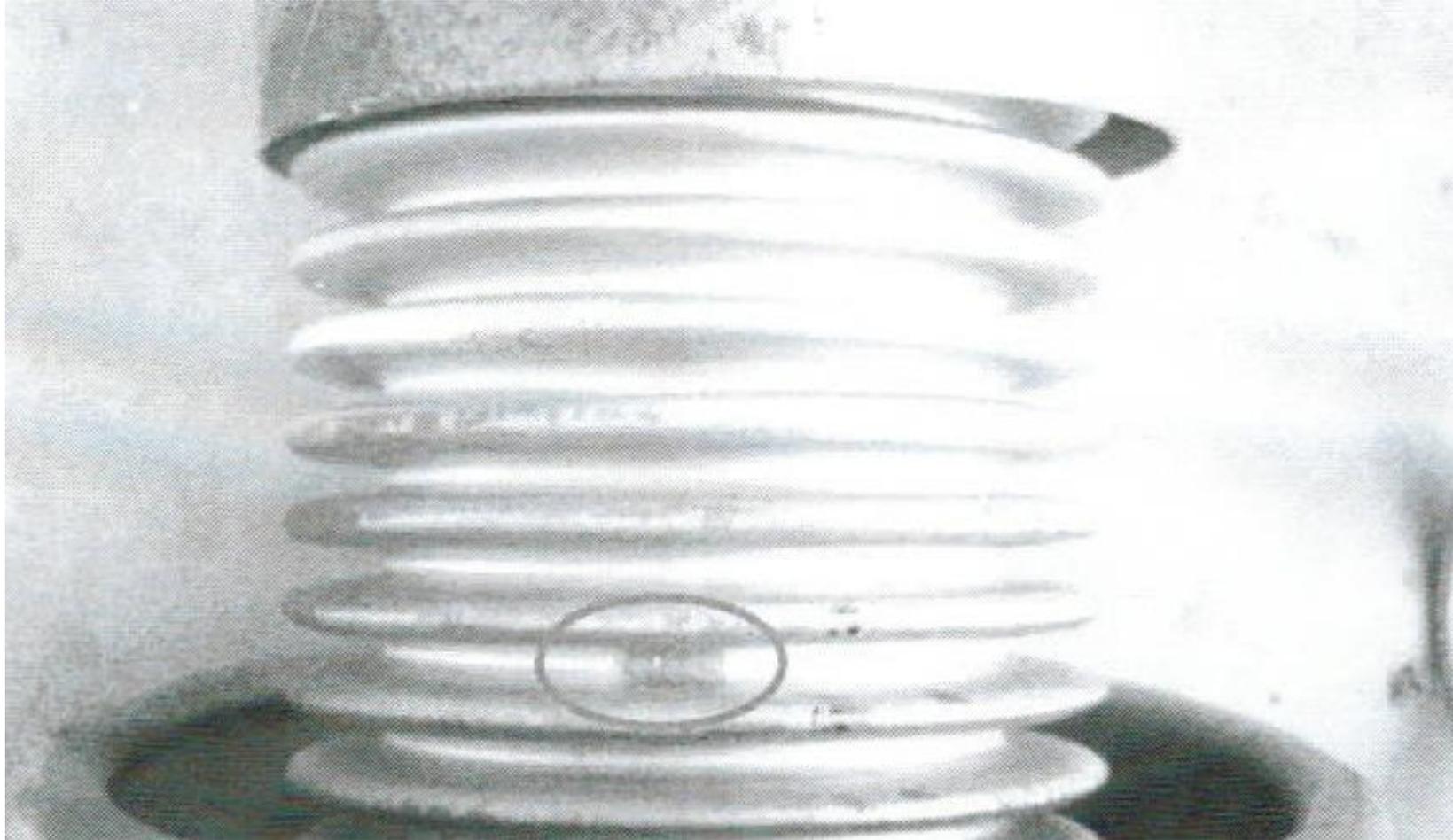
The Vacuum Interrupter



Mechanical Testing After Failure



Pin hole from Chloride contamination of bellows at Mfg

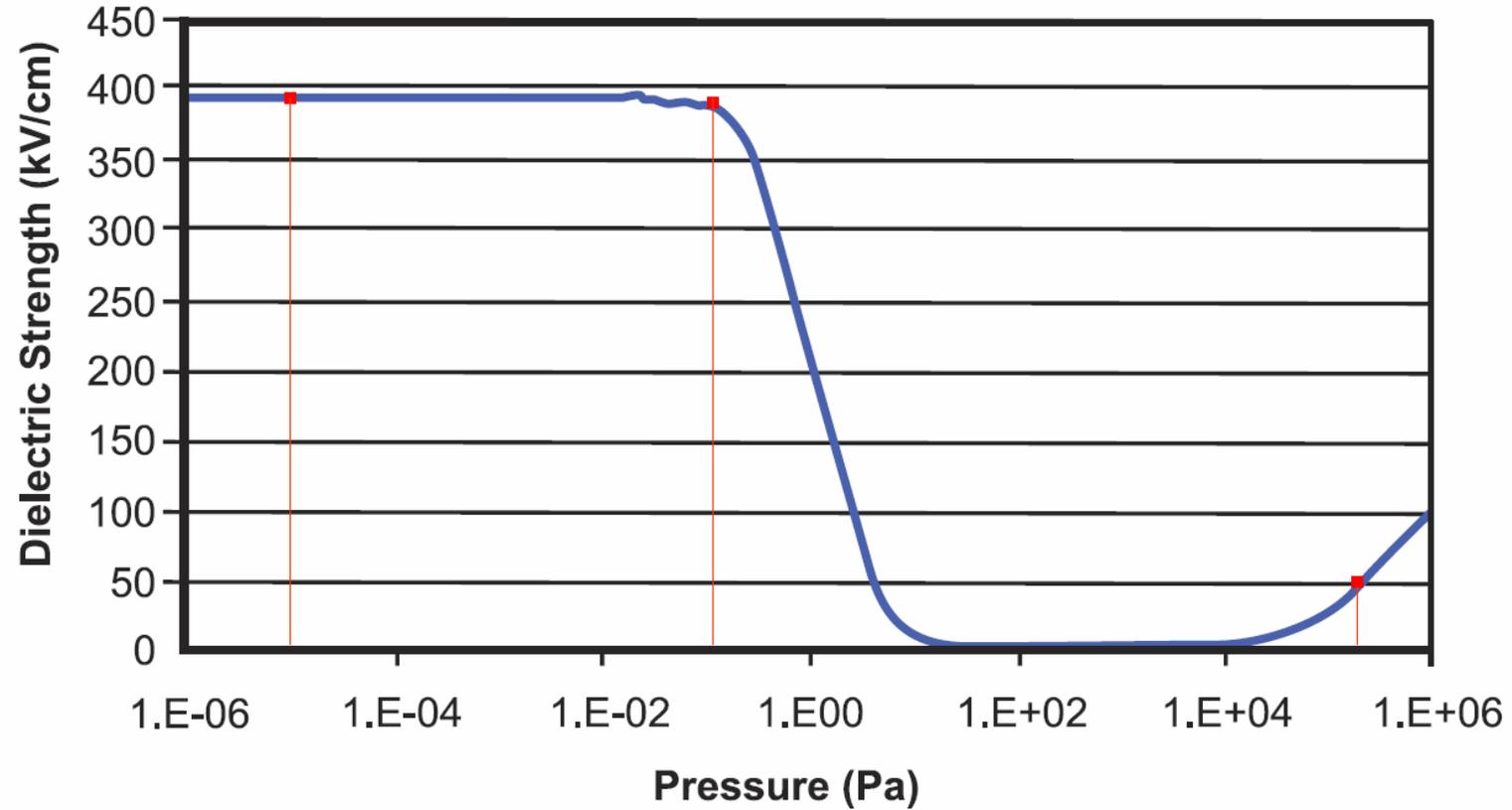


The Findings

- Over 40 Vacuum Breakers were tested.
- 5 additional VI were found to have to have high pressure moving quickly toward failure .
- None of these would have been discovered with typical AC high potential go/no-go testing.
- Issue 1: Possible danger to operator and maintenance personnel.
- Issue 2: There would be more passive or catastrophic failures causing unexpected downtime.
- Issue 3: Equipment failures would not be picked up until a maintenance cycle outside of manufacturers warranty.

Breakdown Voltage

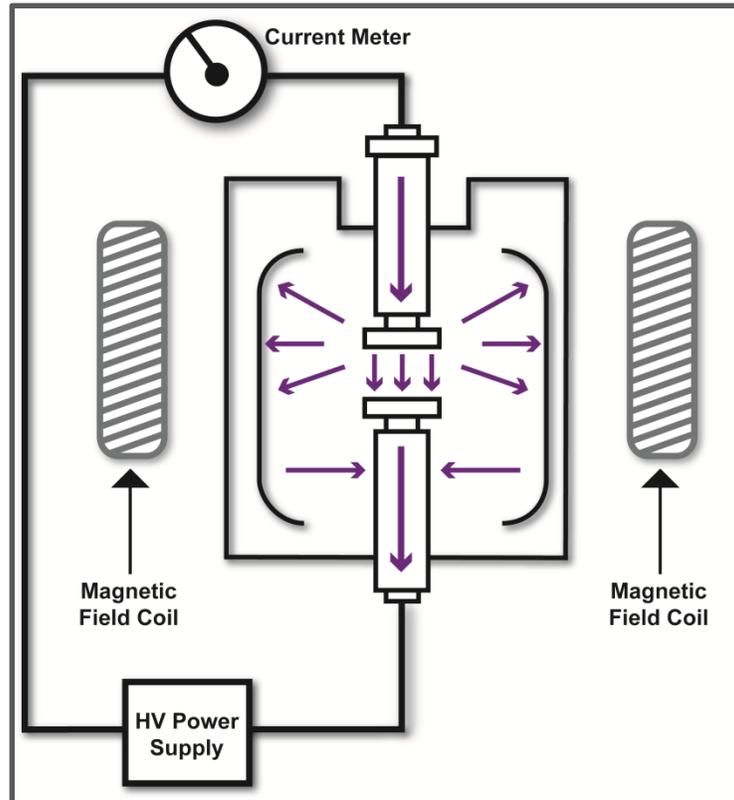
Paschen Curve for Dry Air



Penning Discharge Mechanism

- Charged particles (ions) can be generated from high voltage supplied across an open vacuum interrupter. When a strong magnetic field is applied, these ions will move, thereby, producing a current across the open contacts. This ionization current is directly proportional to the pressure inside the vacuum interrupter. With a known pressure-ionization current curve, the pressure inside a vacuum interrupter can be easily determined through the Penning Discharge principle.

Penning Diagram and Field Testing



Test Setup using Penning Discharge Principle.



Flexible Magnetic Field Coil

A flexible field-based magnetic coil for testing vacuum interrupters while installed in a breaker/contactors. The flexible magnetic coils are used in conjunction with the MAC-TS4 tester.



The Solution

- Identify the vacuum interrupters with increased leak rates.
- Either calculate and replace ahead of failure or replace immediately.
- Feedback to manufacturer of the circuit breakers which model and manufactures or interrupters the issue were with.
- The manufactures introduced a leak test metric into its QA program to stop this from happening again.
- Incoming stocks of Vacuum interrupters are tested upon receipt then again before shipment to calculate leak rates. Any in excess of $3E-7Pa$ per weeks are returned to the supplier.

Need for Pressure Testing

History

- The majority of vacuum interrupters were installed in the 1980's and given an original life expectancy of 20 years.
- Vacuum interrupters installed during this period have far exceeded their manufacturer specified life expectancy.
- Failure of a vacuum interrupter could result in unnecessary downtime and damage to surrounding equipment.

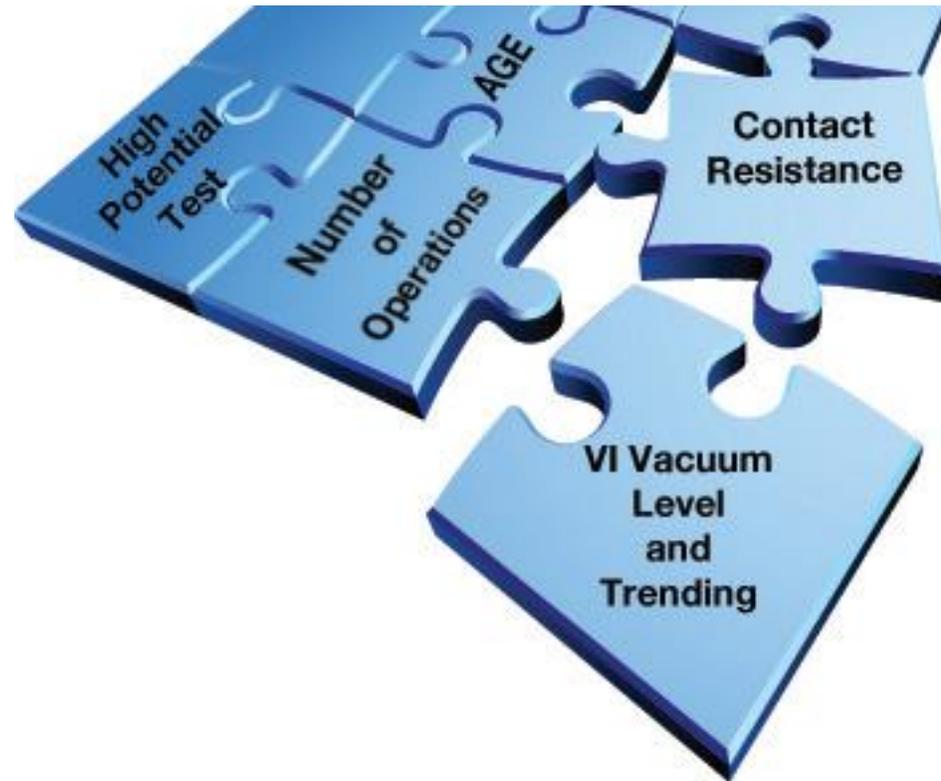
Traditional testing methods

- Pass or Fail test. (Hi-Pot)
- Not capable of determining level of vacuum inside interrupter or life expectancy of vacuum interrupters.

The Future

- There were 5 different vacuum interrupter manufactures used in these 40 breakers
- The 5 vacuum interrupters that failed in the start up phase of the system and the 4 found with high pressures during the investigation were all from the same manufacturer.
- All of the other 200 interrupters from 4 other manufacturers produced test results indicting internal pressures similar to new.
- This rules out installation test or local conditions from the root cause investigation only leaving poor manufacturing or a batch issue.

The Last Piece of the Puzzle



Questions?





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