

**Medium Voltage Primary Cable
Failure Rates and Why Failure Rates
Are Low at
Wisconsin Public Service Corp.**

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Gas & Electric Utility

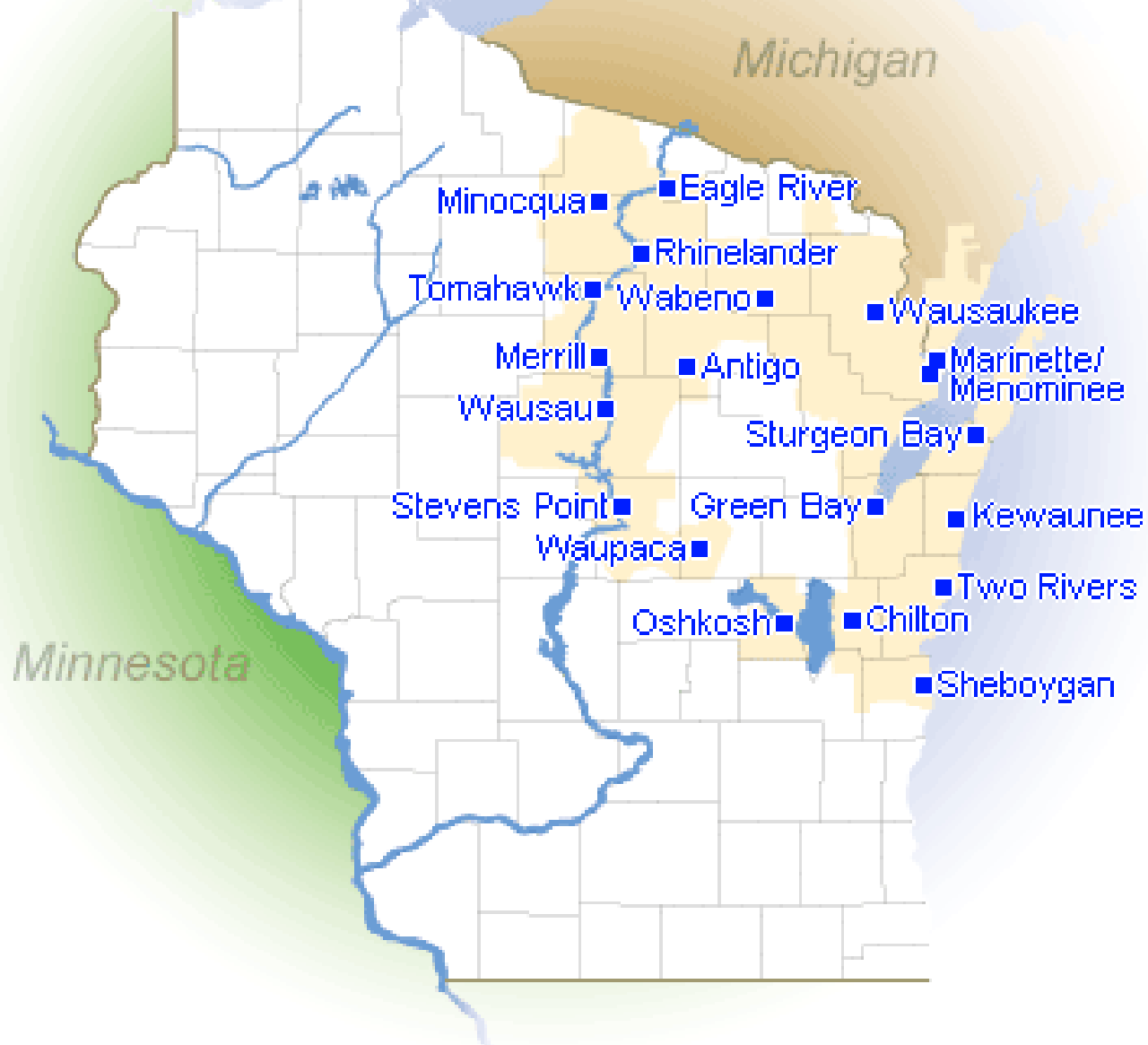
Operates in 11,000 Square Mile Area

400,000 Electric Customers

6,000 Miles Primary Underground

85% of distribution system 14.4/24.94 KV

WPSC Service Territory



Introduction

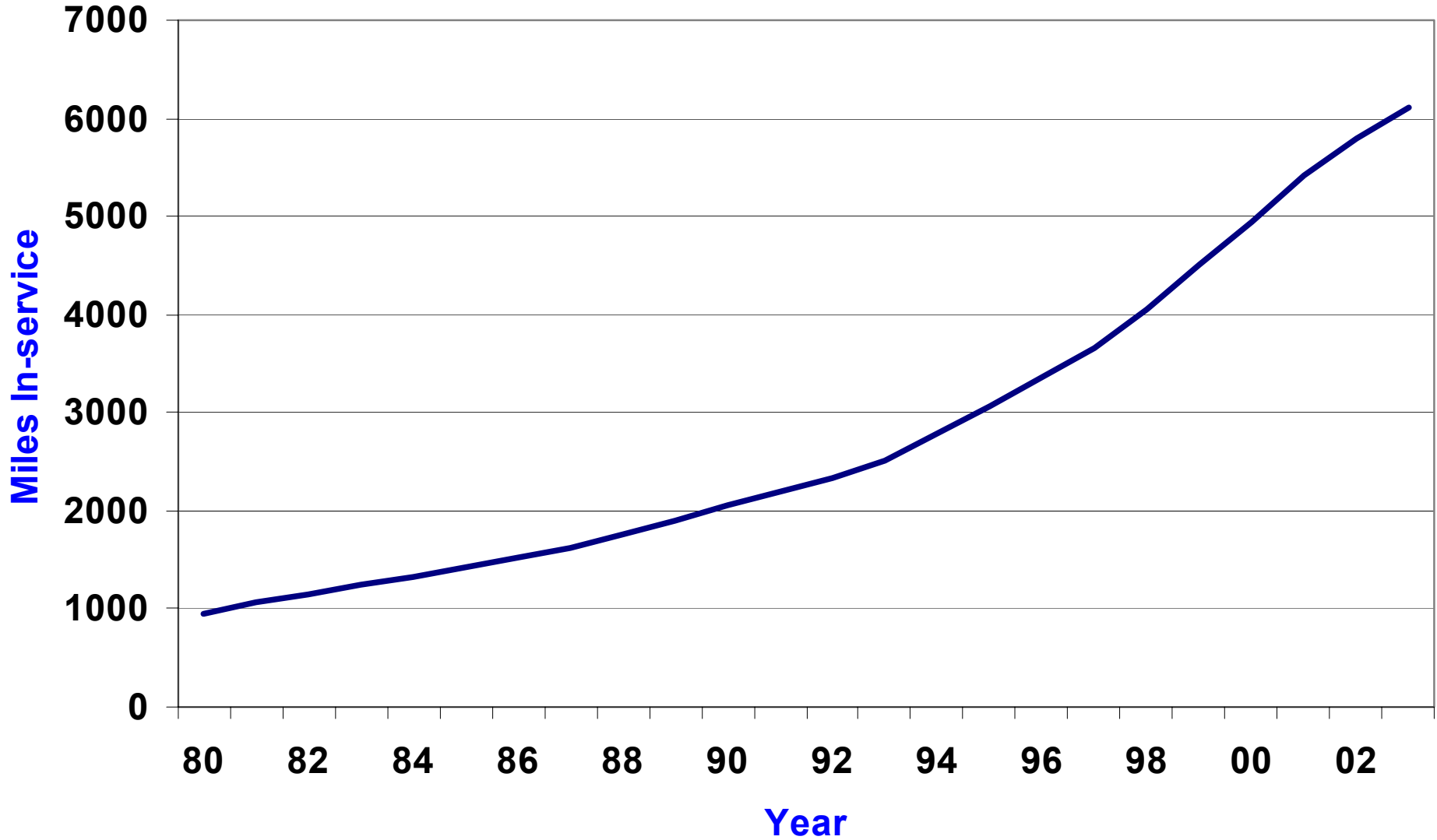
- **Primary Cable Designs and Failure Rates**
- **Why Low Failure Rates**
- **Problems Found**
- **Manufacturer Feedback**
- **Primary Cable Performance Summary**

Cable Designs Used At WPSC

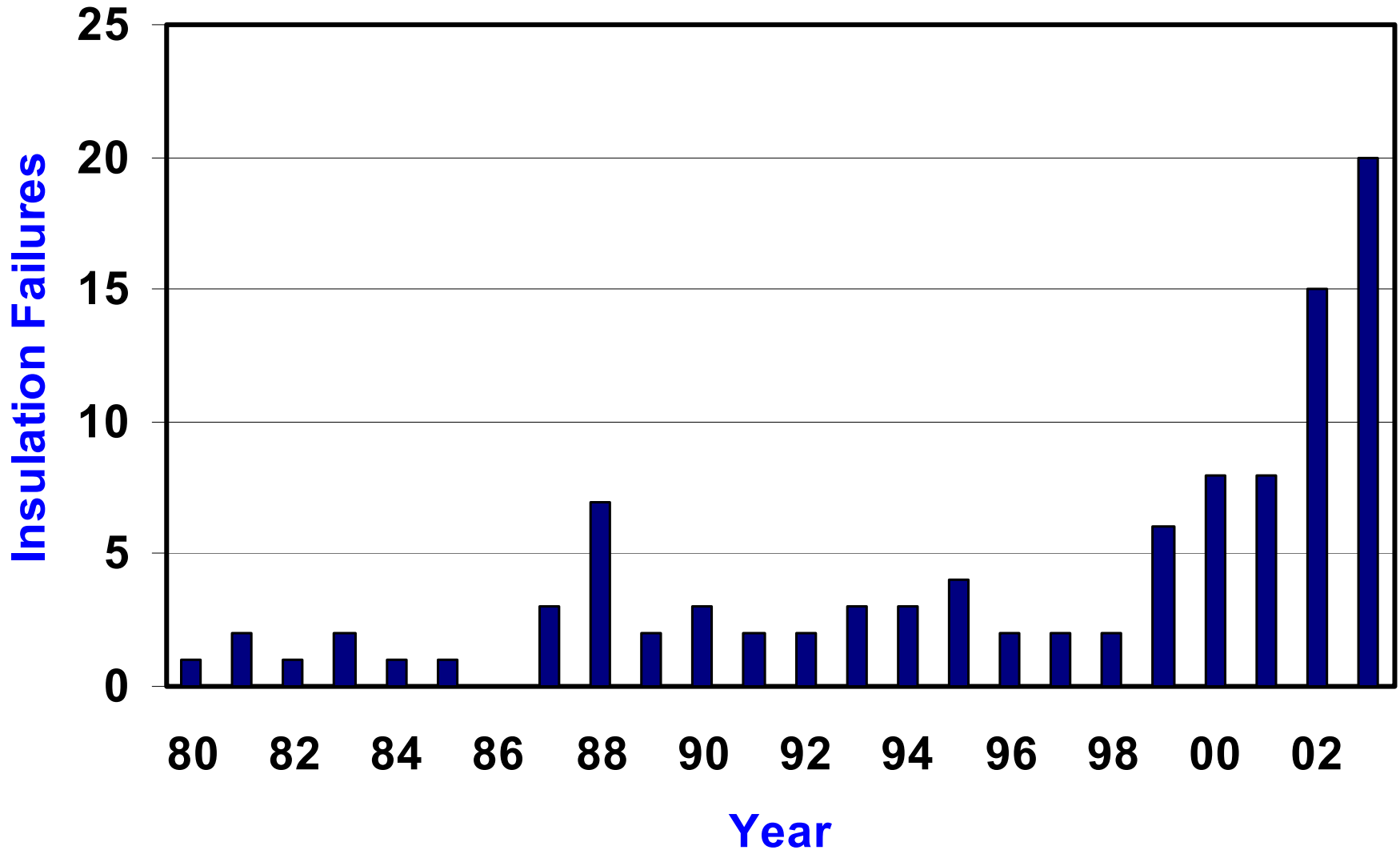
- **220 Mil XLPE 1965-1968**
- **280 Mil XLPE 1968-1985**
- **280 Mil TRXLPE 1985-2004**
- **260 Mil TRXLPE 2004**

Majority of Cable Installed is Direct Buried

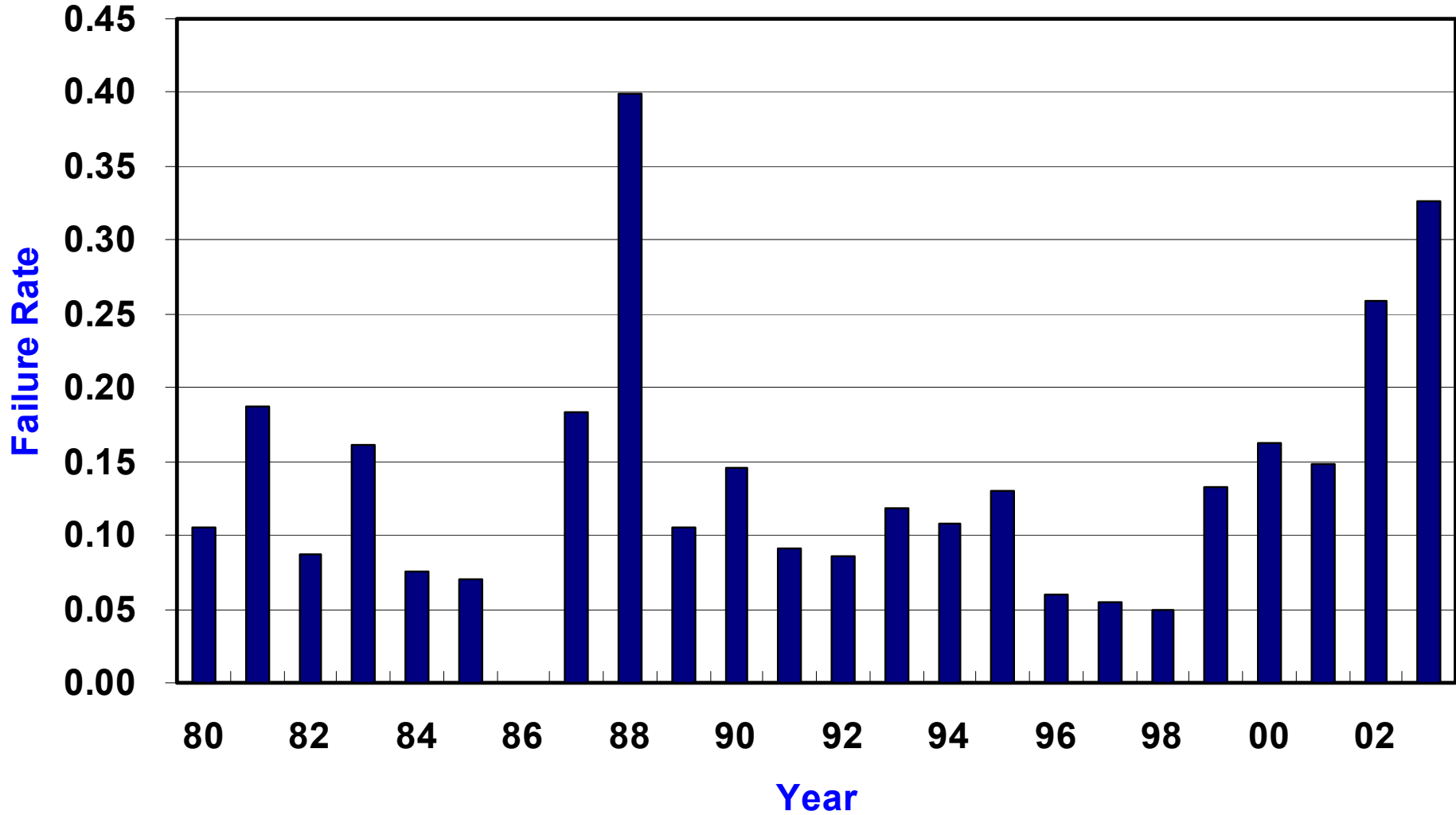
Miles of Primary Cable In-service at WPSC



WPSC Primary Cable Insulation Failures



Primary Cable Annual Failure Rate Per 100 Miles Installed



Low Primary Cable Failure Rates Result In

- **No Annual Budget for Cable Replacement**
- **Two Technicians Perform Cable Fault
Location Testing Company Wide on a
Part-time Basis**

Why Low Failure Rates

- **Arrester Protection**
- **Field Testing Awareness**
- **Training on Proper Cable Handling**
- **Testing Incoming Cable**
- **Manufacturer Feedback**

Arrester Protection

- **Riser Pole Arresters Used Over 25 Years**
- **Under-Oil Arresters**
 - Single Phase Padmounts Since 1987
 - Three Phase Padmounts Since 1999

Field Testing Awareness

- **Limited Number of Technicians Involved**
- **Hi-Pot Insulation Testing Avoided**
- **Thumping for Faults**
 - Radar Narrows Faulted Cable Search Area
 - Limit Discharge Duration
 - Limit Voltage Used

Cable Handling

➤ Proper Cable Handling

- Line Crews
- Contractors
- Warehousing

➤ Problems Found & Reported By:

- Warehousing
- Installation Personnel

Testing Incoming Cable

- **Contamination**
- **Ambers**
- **Shrinkback**
- **Shield Irregularities**

Examples Problems Found

- **Contamination - Various Types**
- **Ambers - Large Quantities/Sizes**
- **Shrinkback - Excessive**
- **Shield Irregularities**
- **Butt Welds - Conductor and Neutral Strands**

Contaminant

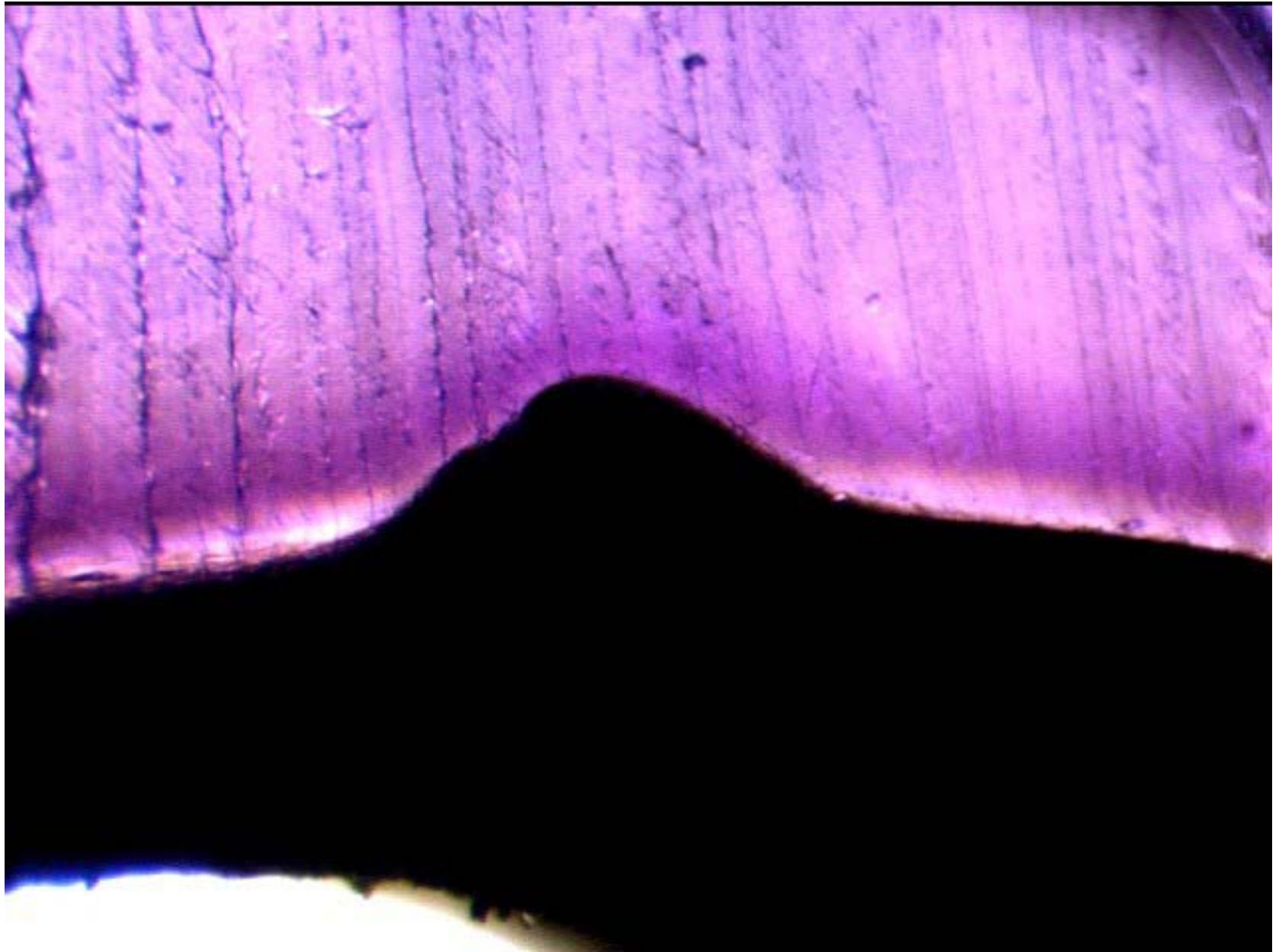
Black Contaminant



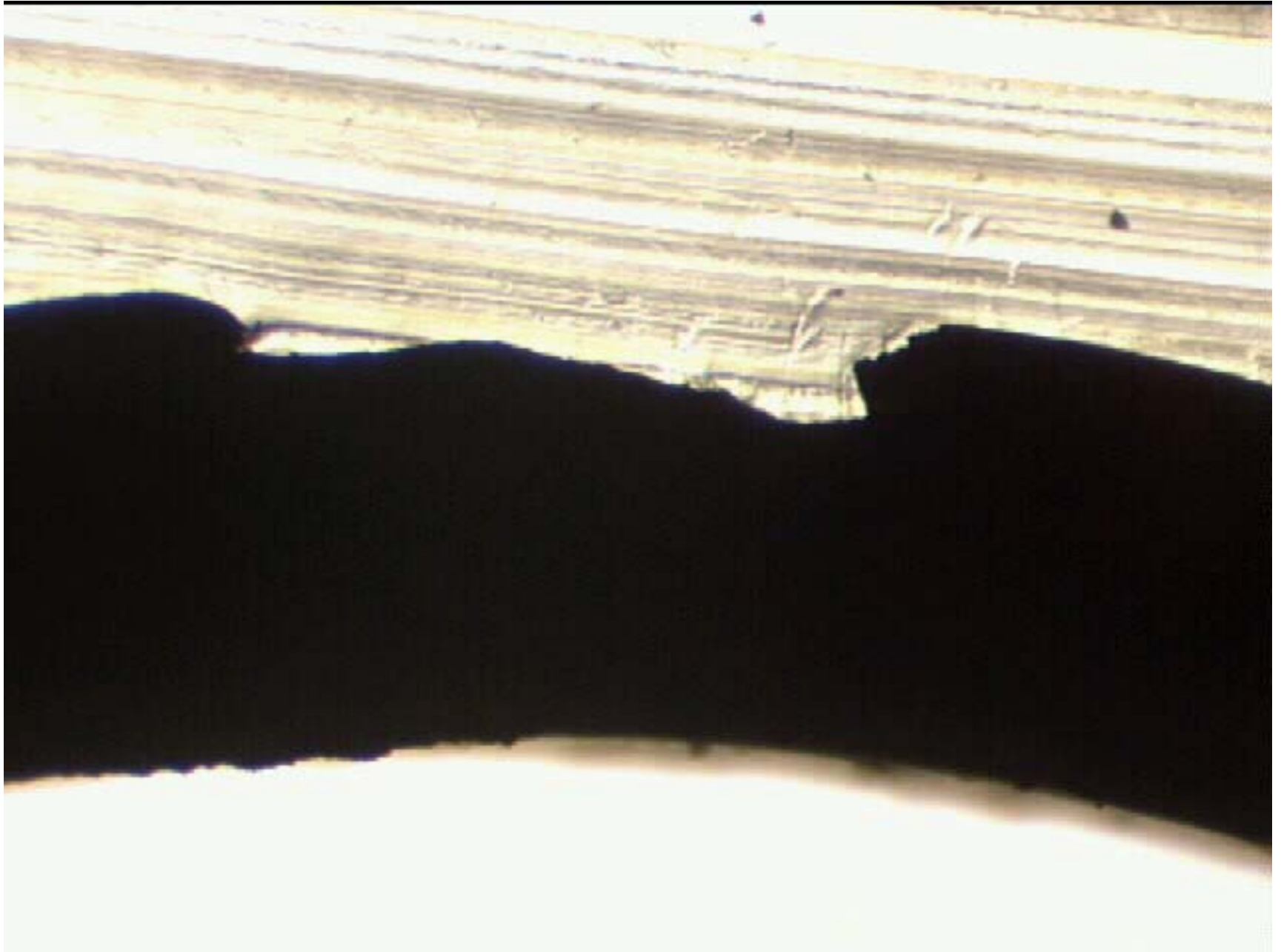
Amber



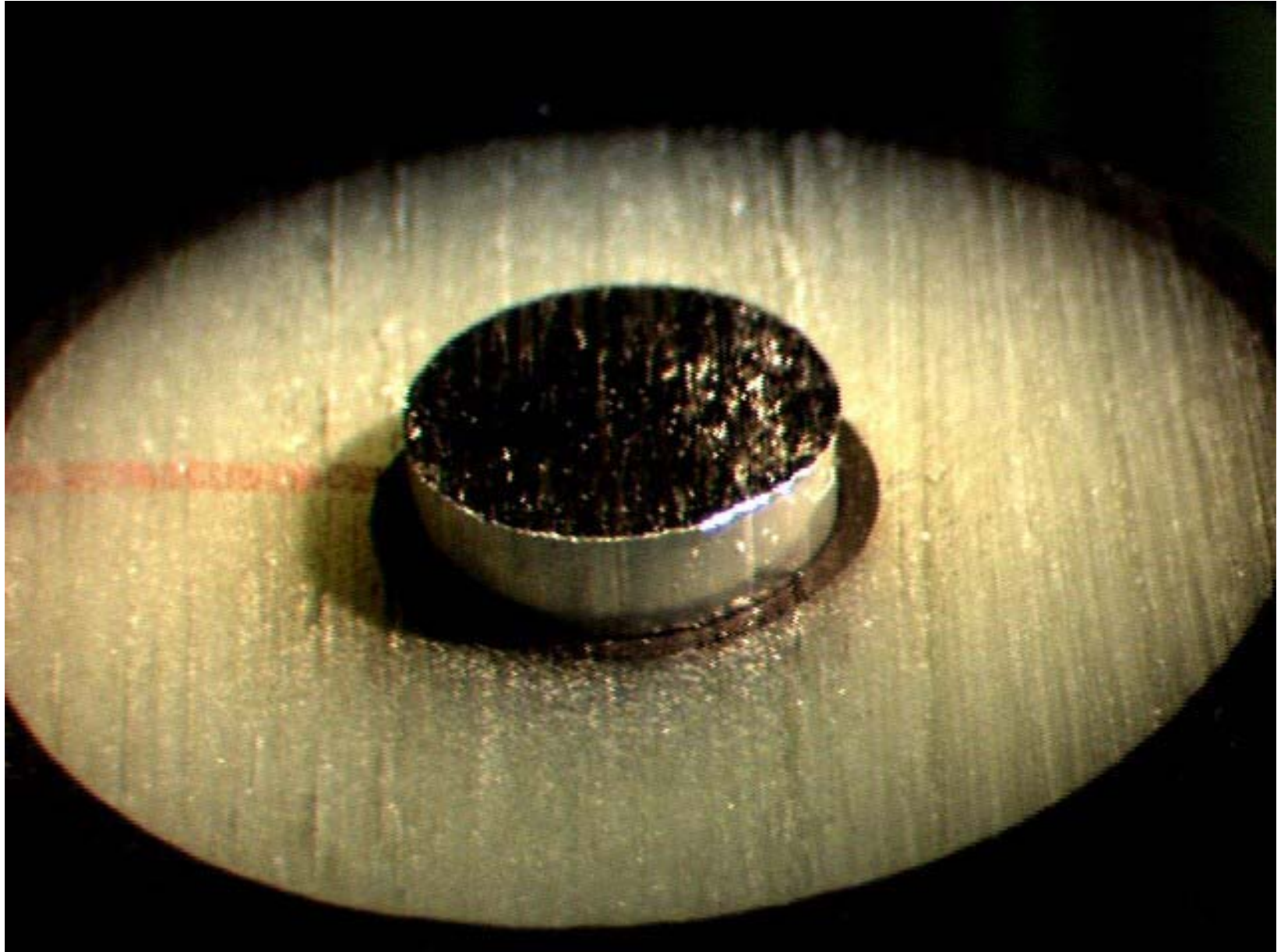
Shield Protrusion



Poor Shield Construction



Shrinkback



Elbow Failure Due to Extreme Shrinkback



Shrinkback Failure-Elbow Removed



Testing Program Found

- **Continuous Monitoring of Supply Required**
- **Cable Quality Varies Year to Year**
- **Problem Types Vary**
- **Intensity of Problems Vary**
- **Improves Manufacturing**

Manufacturer Feedback

- **Problems Found Reported to Manufacturer**
 - Limit Quantity Received
 - Determine Causes
 - Determine if Cable Life Affected
- **Good Manufacturer Working Relationships**
 - Technical Support
 - Quality Assurance

Results of Manufacturer Feedback

➤ **Manufacturing Processes Improved**

- Raw Materials
- Handling Raw Materials
- CV Operation
- Quality Control Testing

➤ **Cable is Improved**

- WPSC Cable
- Industry Wide

Summary Primary Cable Performance at WPSC

- **Good Operational Performance Result Of:**
 - Proper Cable Handling and Installation
 - Good Over Voltage Protection
 - Proper Cable Manufacturing
- **Failure Rates Remaining Low**
- **No Evidence Requiring Annual Planned Cable Replacement in Foreseeable Future**