



**Distributed Strain and Temperature
Sensing in Public Utilities**

OZ Optics Limited

January 2023



Applications



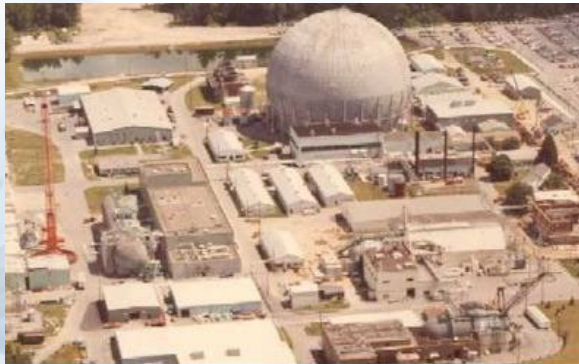
Oil, Water, Gas
Pipeline Monitoring



Dam and Levee
Monitoring



Power Line
Monitoring



Nuclear Power
Reactor Monitoring



Steam Plant
Monitoring



Power Generation
Monitoring

Fiber Optic Sensors

- Advantage of fiber optic sensors
 - Electrically insulating materials (no electric cables are required) — effective in high voltage environments
 - Chemically passive, not subject e.g. to corrosion
 - Immune to electromagnetic interference (EMI)
 - Extremely wide operation temperature range
 - Distributed sensing (few meters to 100 km)
 - Fibers act as both sensor and communication channel
- Distributed Fiber Optic Sensors
 - Brillouin scattering based: both temperature and strain
 - Raman scattering based: only temperature



OZ Optics Foresight™ DSTS Benefits

Total system solution provides:

- Reduced operating expenses
 - Centralized monitoring
- Optimized field engineering resources
 - Automated dispatch with GPS coordinates
- Reduced danger of catastrophic failure
 - Real-time continuous monitoring
 - Corrosion and leak detection
 - Crack detection
- Improved Efficiency
 - Maximized plant operation within design limits



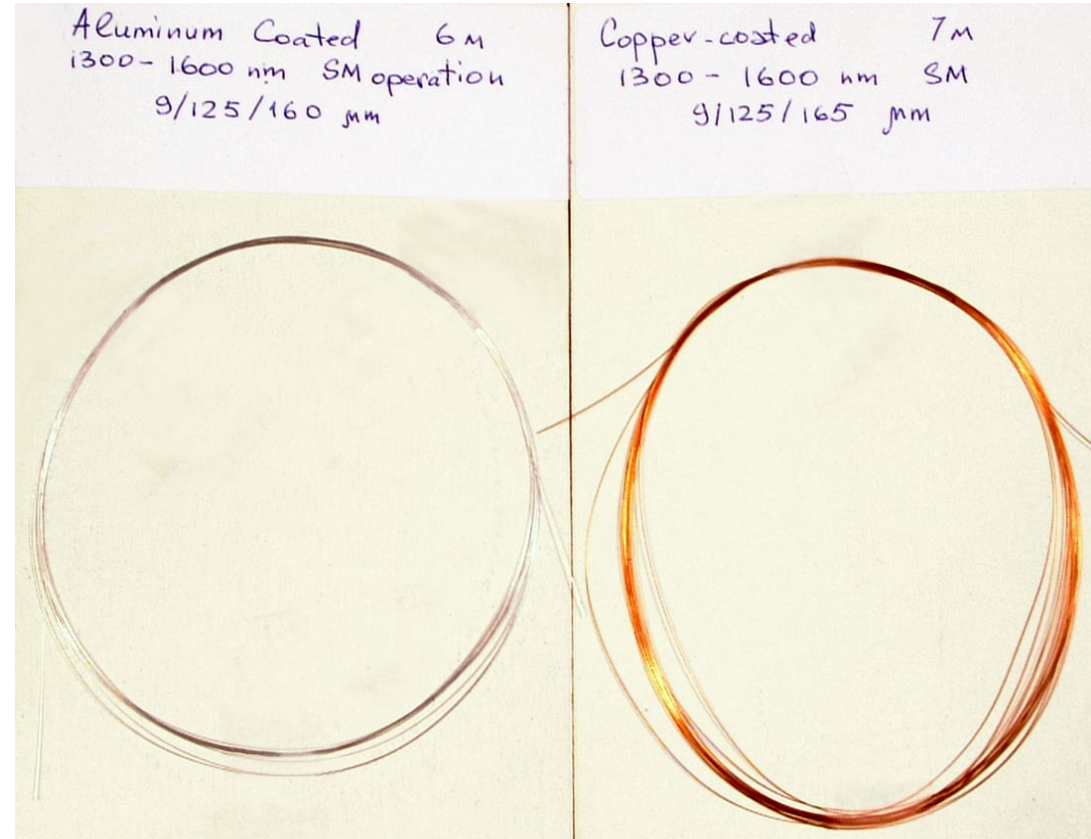
Fiber for all Applications

- High & low temperatures
- Extreme endurance & load
- Harsh environments
- Tight spaces
- Complete integration in structures, facilities and assemblies
- Detects moisture, chemicals, strain, temperature and other variables

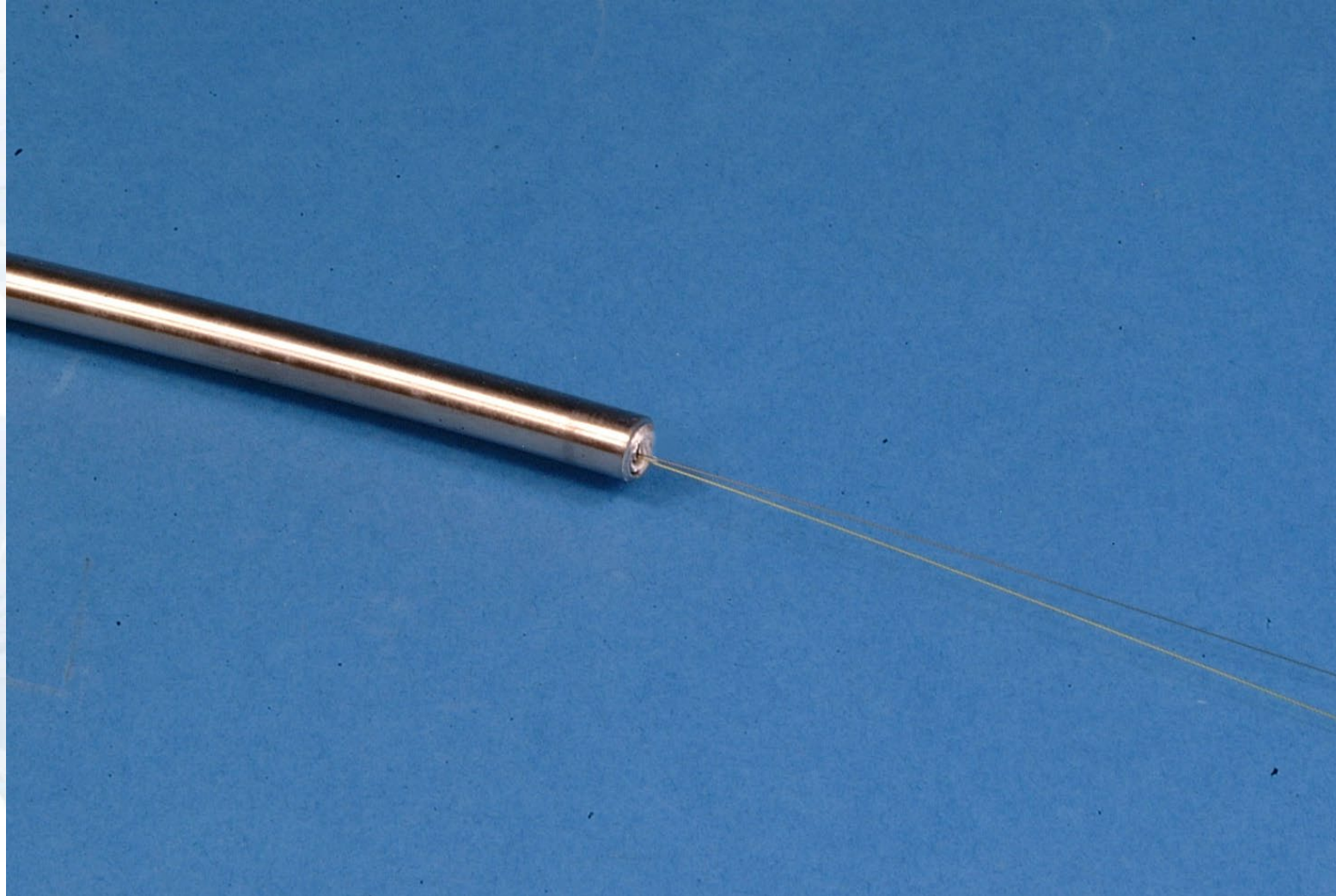
Specialty Fibers for High Temperature

Coating materials and maximum sustainable temperatures

UV-cured acrylate	100°C
UV-cured dual acrylate	150°C
Polyimide	400°C
Copper+polyimide	400°C
Aluminum	450°C
Copper alloy	600°C
Gold	700°C+



Armored Cables for Extreme Endurance





Harsh Environments

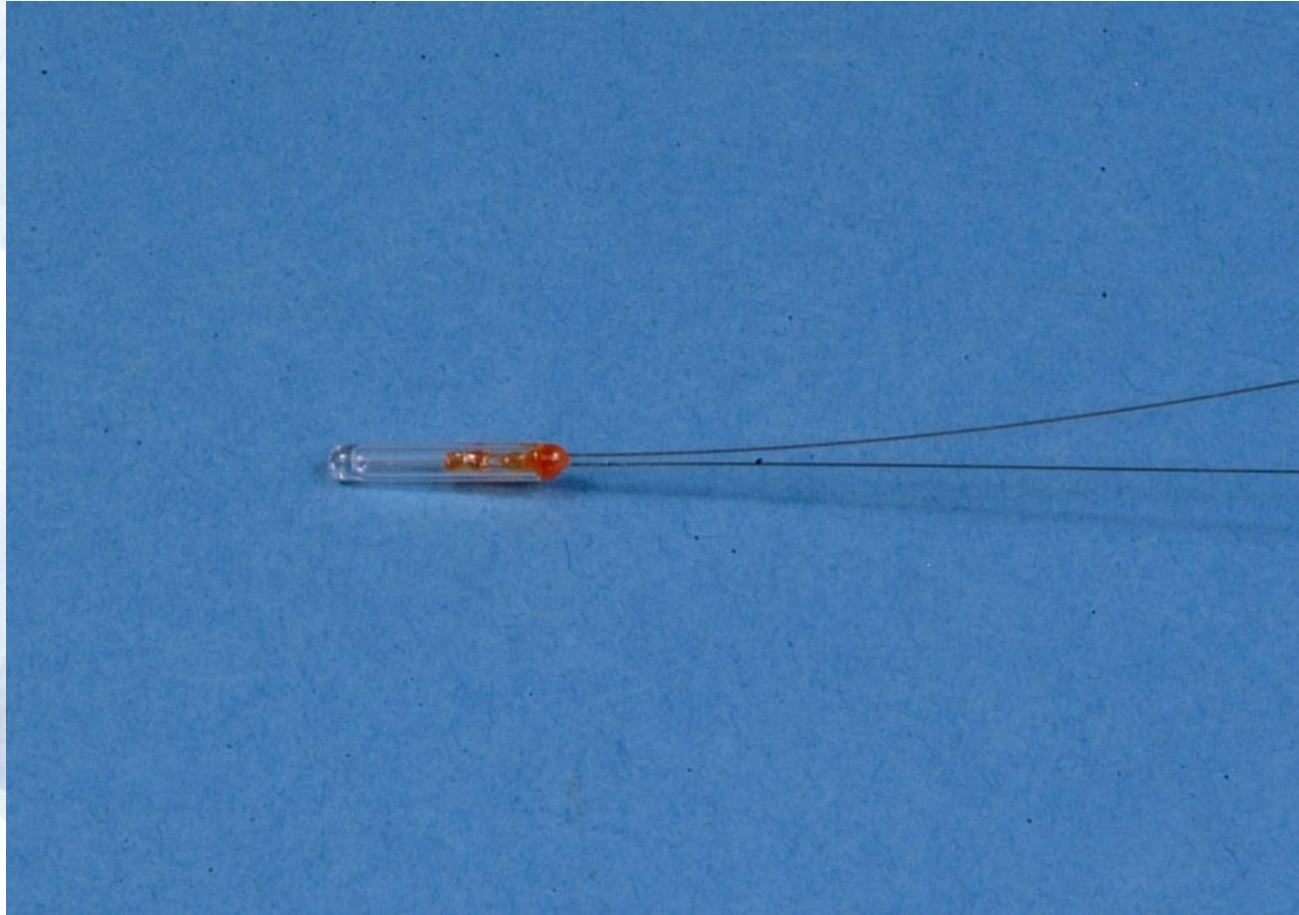
- Specialty Coatings to prevent intrusion into the fiber
- Pure Silica Glass to minimize impact of impurity intrusions
- Increased Doping for required response

Glass coated with carbon, polyamides, metal, etc

Can operate in hydrogen rich environments.

Allows simultaneous strain and temperature info

Newly Designed Loop Back Fiber Tips





High Voltage Underground Cable with Fiber





Fiber matched to application

DSTS applications are nearly endless. Fibers can be coated, jacketed, looped, integrated into larger cables, and even simply laid bare onto surfaces. Strain and temperature can be measured separately using the OZ Optics Foresight DSTS.

Matching the fiber cladding, jacketing, cable design and loop requirement has moved DSTS from laboratory test to field trials and then on to full deployment.

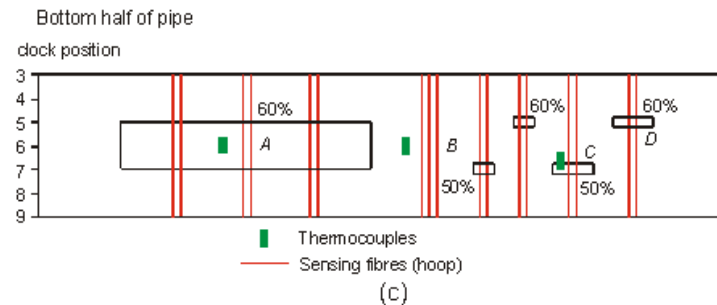
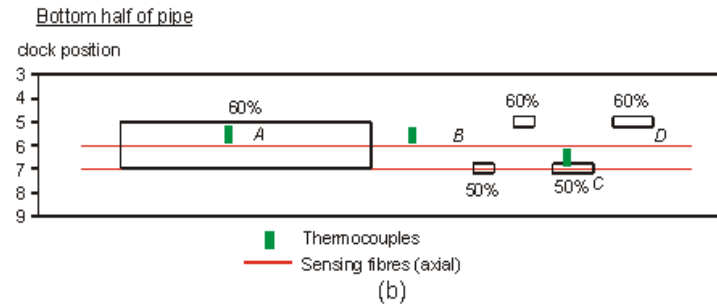
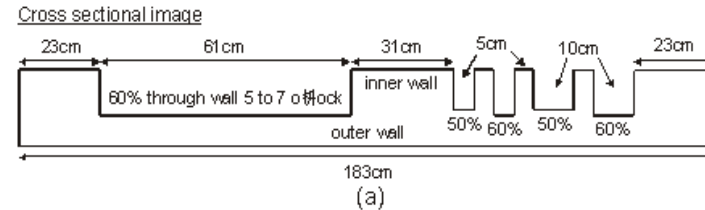
A few applications follow.

Applications of Foresight™ DSTS

Pipeline corrosion monitoring in Canmet Materials Technology Laboratory, NRCan, Ottawa, NACE International — Corrosion 2008 Conference and Expo, New Orleans (Louisiana, USA 16-20 March, 2008).



Extended accelerated corrosion testing is underway. 1 year of testing data to be available January 2010.

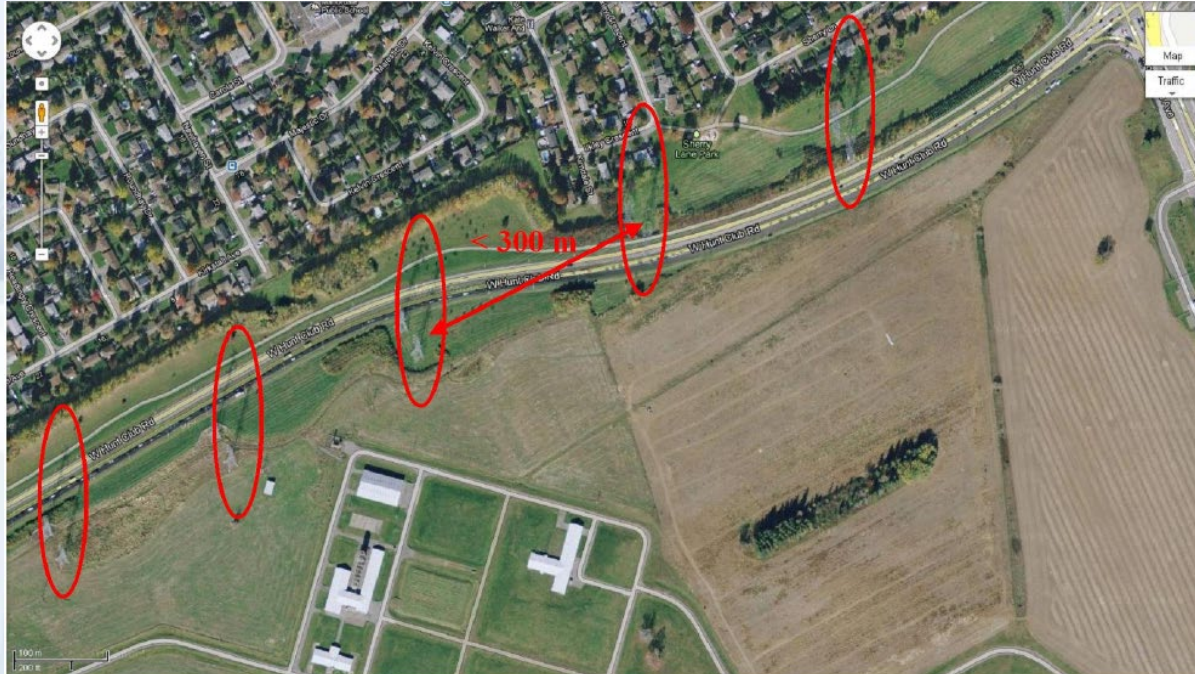




OPGW Monitoring

- Monitoring the working status of OPGW
- Abnormal event found and located
- Event caused by broken strand, lightning, frost covering, change of strain, etc..

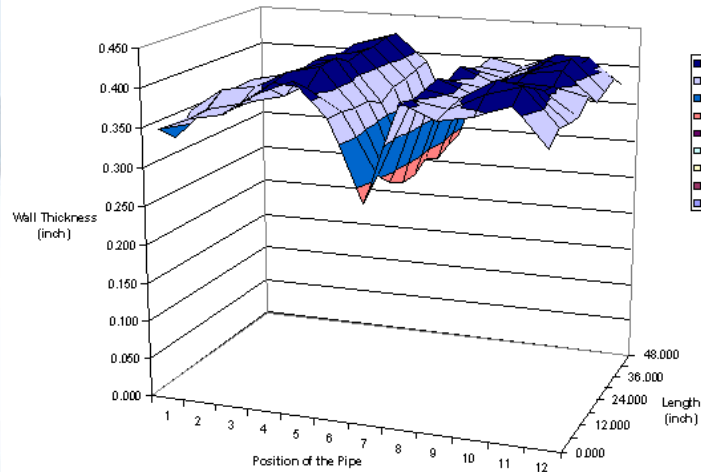
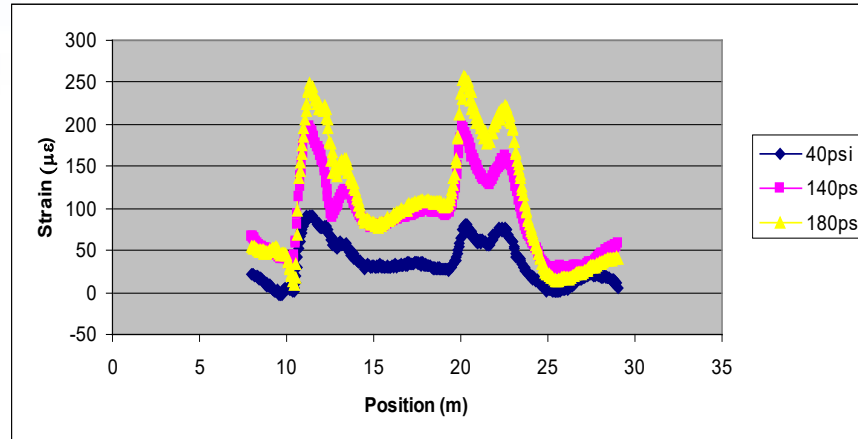
▶ OPGW Status Monitoring



- The OPGW is located from Smith Falls to Merivale-Ottawa, Ontario, Canada.
- The total fiber length was close to 140 km.
- The BOTDA located in Merivale-Ottawa made measurements as often as once every 60 minutes starting in June 2012 and continuing till July 2013.

Applications of Foresight™ DSTS

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Applications of Foresight™ DSTS

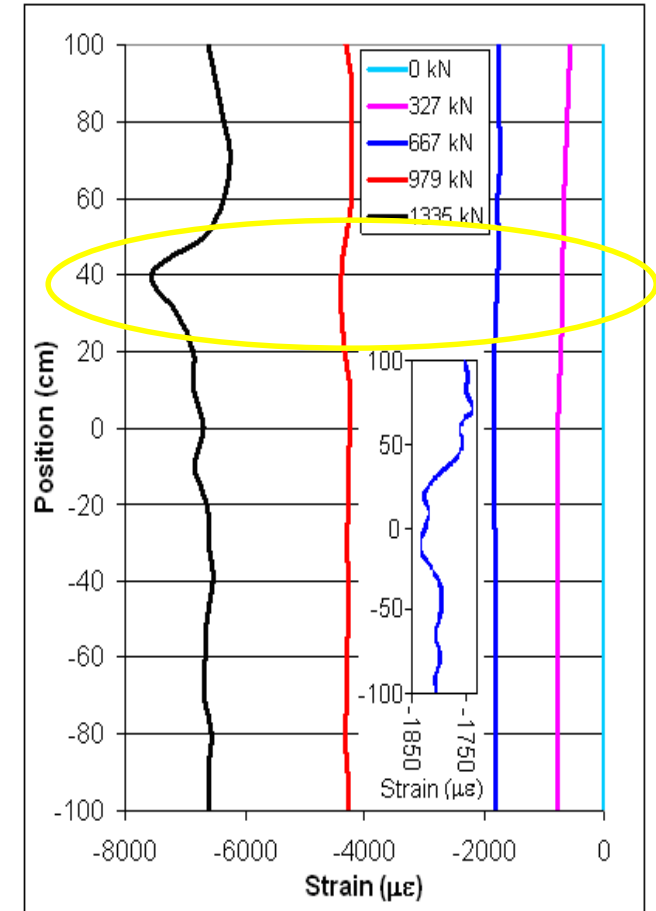
- Concrete beam/Highway monitoring on HW40/University of Sherbrooke, Dr. Brahim Benmokrane



- Fibers protected from directly poured concrete. Strain performance verified for utilization new support structure.

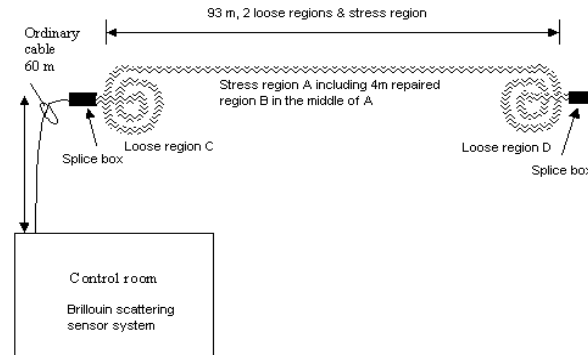
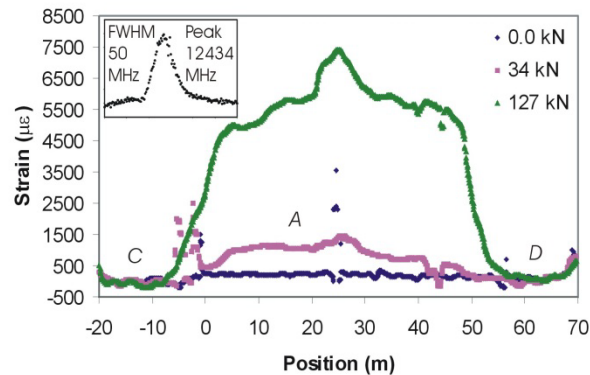
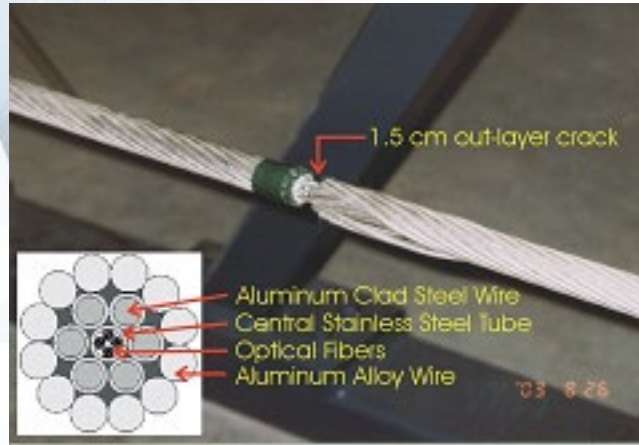
Applications of Foresight™ DSTS

- Pipeline buckling detection in TransCanada Pipeline Ltd, Calgary, and C-FER Technology, Edmonton



Applications of Foresight™ DSTS

- Power line/OPGW monitoring in Hydro-Quebec, Montreal

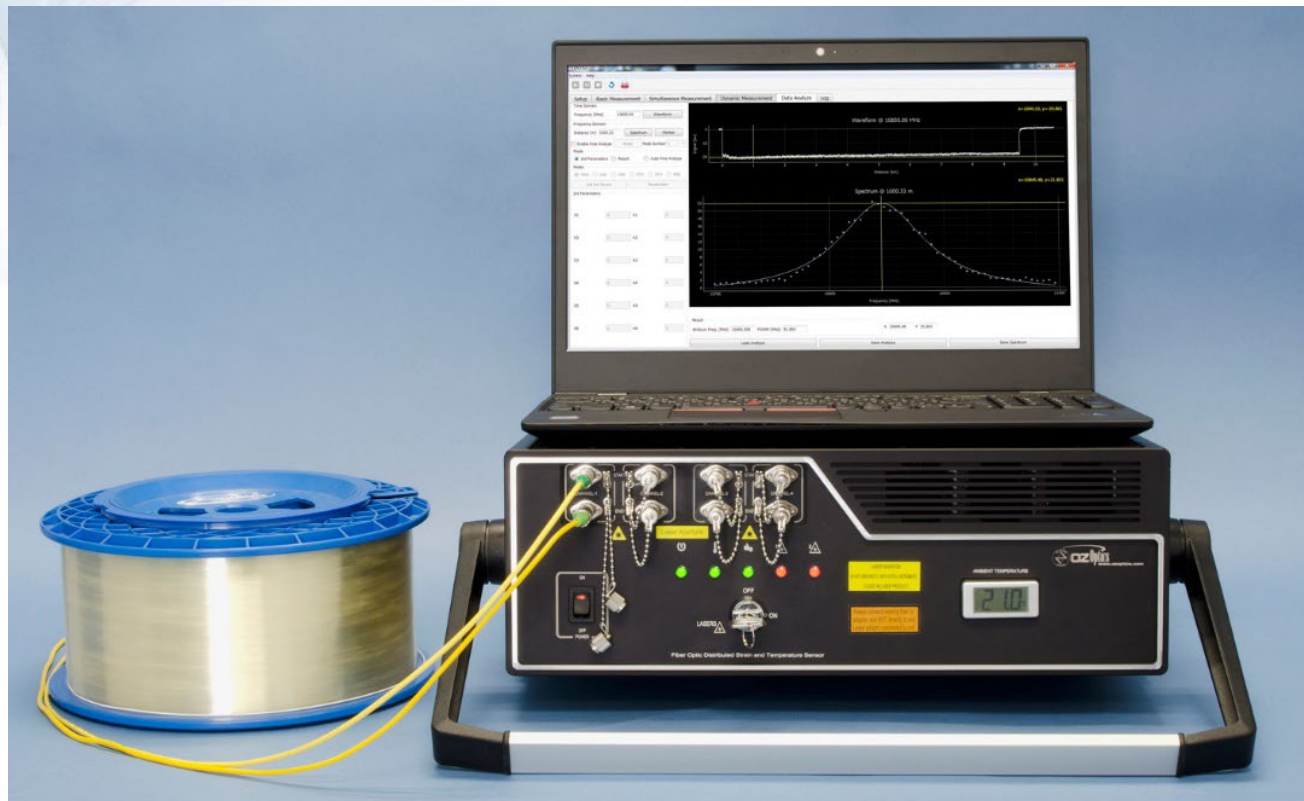




OZ Optics Foresight™ DSTS



Actual product



Rack mount version shown

Summary of Performance

- Measurements every 5 cm for up to 10 km
- Discern separate events every 10 cm
- Temperature resolution of 0.005°C
- Temperature accuracy of 0.1°C
- Strain resolution of $0.1 \mu\epsilon$
- Strain accuracy of $2 \mu\epsilon$
- Typical temperature range: -270°C to $+1000^{\circ}\text{C}$
(dependent on fiber)
- Compression of -2% and elongation of $+3\%$
(dependent on fiber)



Raman versus OZ Foresight™ DSTS



	Raman based	OZ Foresight™ DSTS
Maximum distance	20 km	100 km round-trip (physical distance 50 km)
Fiber Type	Multimode	Single mode standard telecom
Response time @ 20km, 2C Resolution	More than 10 minutes	2 Seconds
Configuration	Single end	Loop / double end, single end is also available
Measurement base and accuracy	Intensity based, require calibrations, sensitive to changes in attenuation	Frequency based, after setup, no calibrations required, not sensitive to changes in attenuation
Dynamic range	3-4 dB, may fail to measure when attenuation increases	25-30 dB, allows better immunity to attenuation, wider measurement range and longer use of installed fiber
Measurement types	Temperature only	Temperature and strain
Measurement resolutions	Comparable @ over 10 minutes	Comparable @ several seconds



Acknowledgements

- University of California, Irvine, Dr. Maria Feng
- University of Ottawa, Dr. Xiaoyi Bao
- University of Sherbrooke, Dr. Brahim Benmokrane
- TransCanada Pipelines Limited (TCPL)
- C-FER Technologies
- Canmet Materials Technology Laboratory, NRCan
- Hydro-Quebec



The OZ Optics Commitment



OZ Optics is committed to providing a complete solution, lab evaluation, and field trial to meet your structural health monitoring requirements.



Thank You for Choosing OZ Optics

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