GUIDELINES FOR OFFSHORE STRUCTURE MONITORING

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When Brazil Rig sank

World realized that petroleum engineers are indeed working with Titanics of 21st century with technology of 18th century

What Is not Done

- Monitoring of anything other than oil and gas production

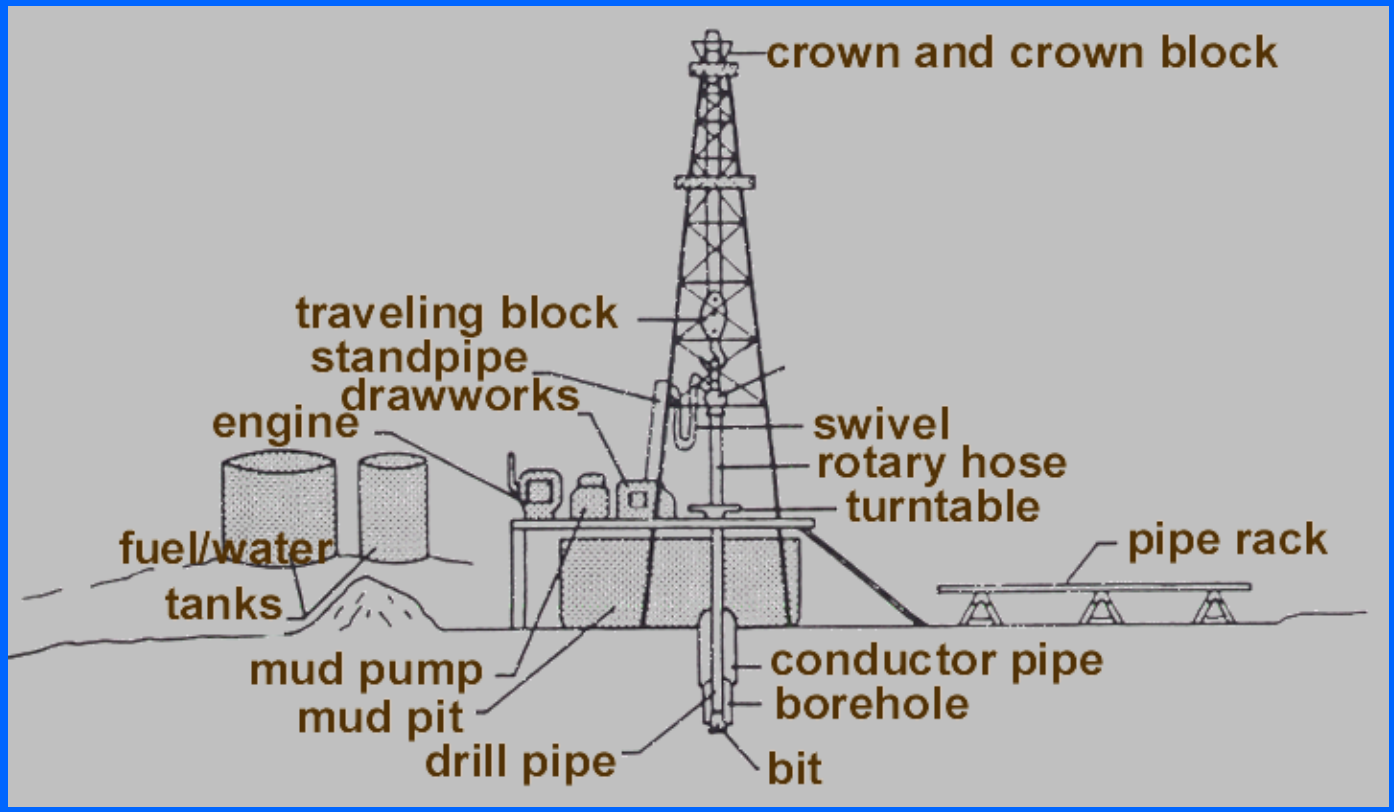
The Structure Design

- From 50's text book
- Even though the rig was labelled as World's largest

Petroleum activities

Offer one of the most difficult conditions from various structural design perspectives

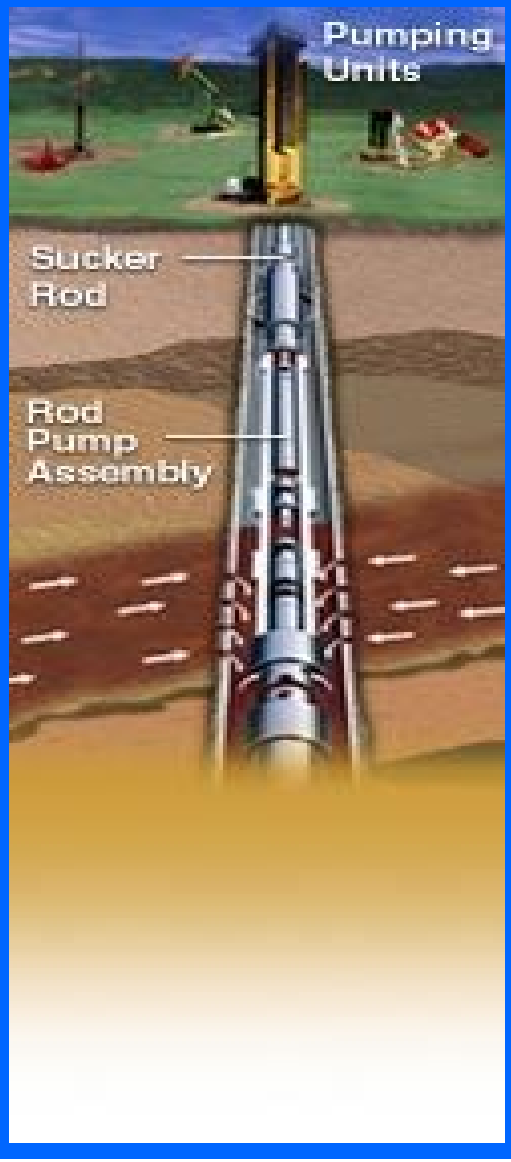
Drilling and Completing



Extreme stress, thermal under anaerobic and aerobic conditions: difficult on and metal

Production Operations

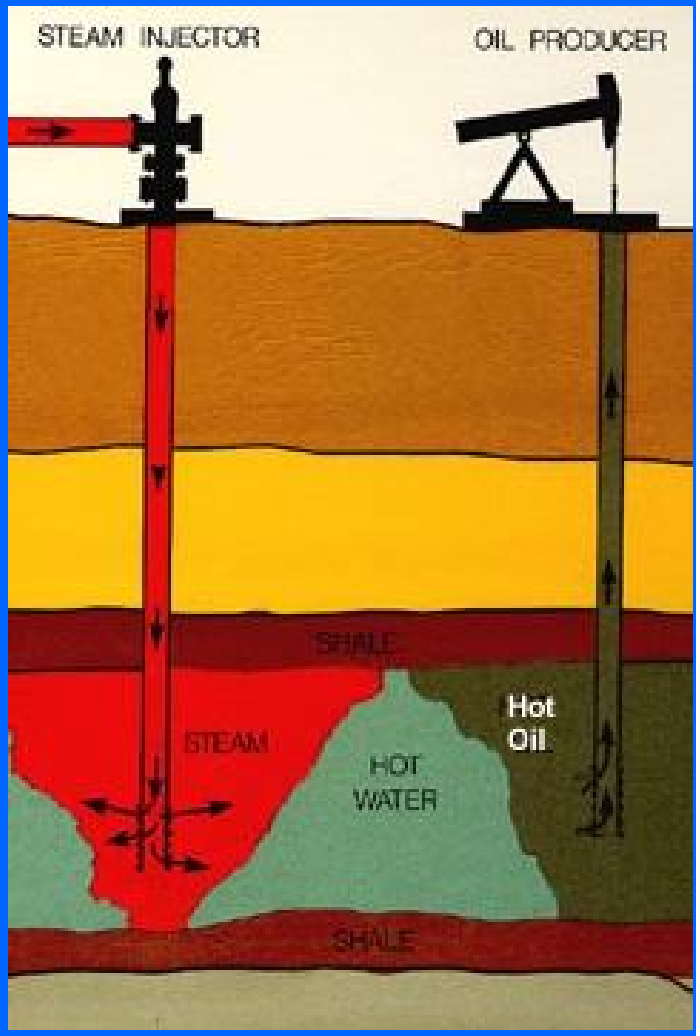
- Extreme conditions
  - microbial activities
  - sour gas (due to bacteria growth)
  - Corrosive environment
  - High Thermal Gradient



Enhanced Oil Recovery

Variable

- Thermal stress
- Chemical composition
- Depletion-induced stress
- Vortex shedding



Offshore Adds Difficulties

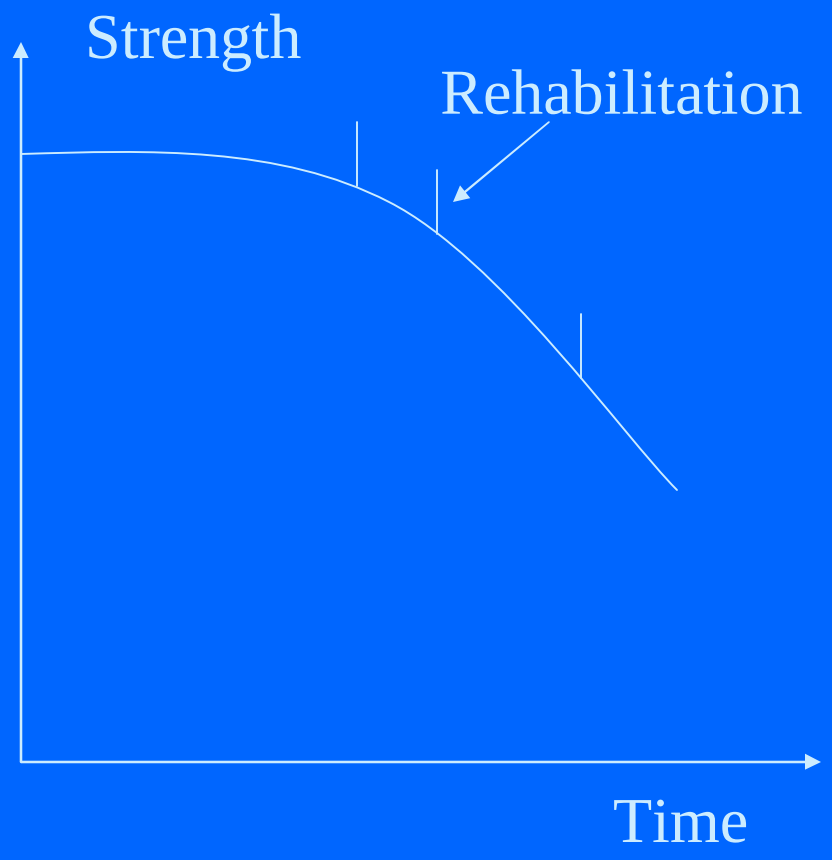
- Tidal waves
- Corrosion
- Wind
- Fatigue
- Salinity
- Thermal shock (steep gradient, seasonal change, fluid injection)

Structural Point of View

- Different parts of the structure will be subject to different conditions
- That is, thermal, chemical, mechanical fluctuations
- Complicated due to the presence of anaerobic, aerobic, salinity, waves, winds

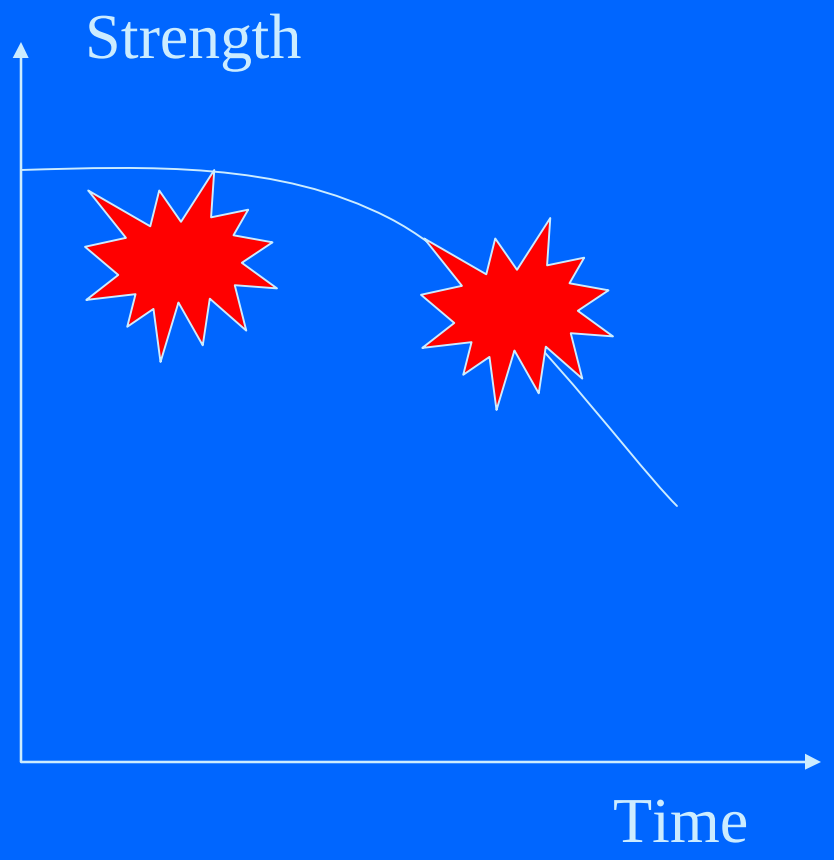
Structural Point of View

- Conventionally, the degradation of the structure with time is not monitored nor known (through theory get the following)
- Rehabilitation works deal with improving strength arbitrarily



Structural Point of View

- An explosion can be handled depending on the age of the structure
- The probability of success decreases with time
  - But can be improved through monitoring



Future Technology (0-10 Years)

- Advanced sensor technology
  - Smart sensors
- Expandable casing technology
- Composite tubing applications
- Riserless Drilling/ Sub sea completions
- Smart wells
- Real time reservoir management
- Gas-to-liquid technology

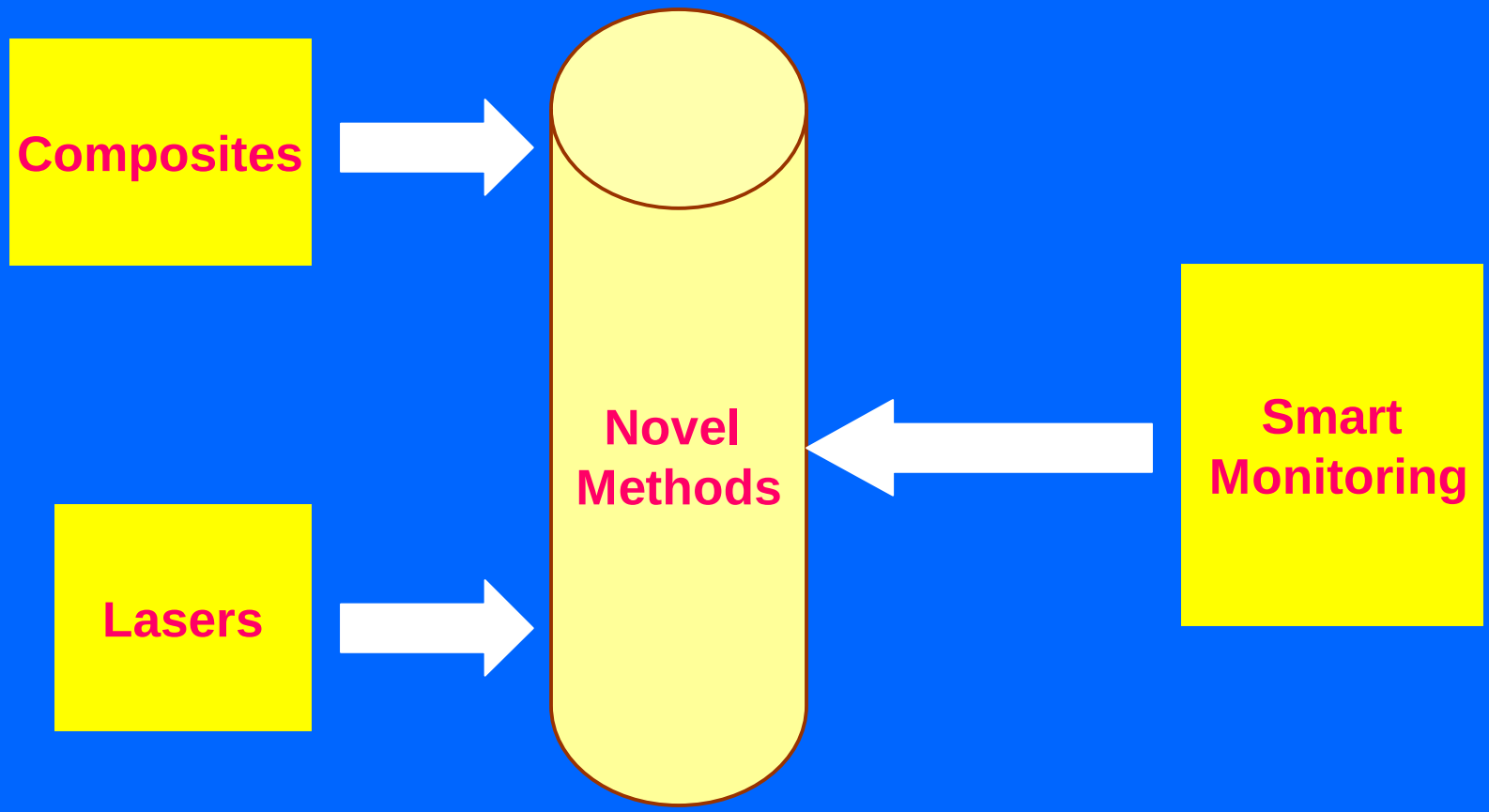
Future Technology (10-20 Years)

- New drilling methods
- Borehole-to-borehole tomography
- Down hole refinery
- Exploitation of gas hydrate reservoirs
- Ultra deep water capabilities (10,000 ft)

Structural Needs

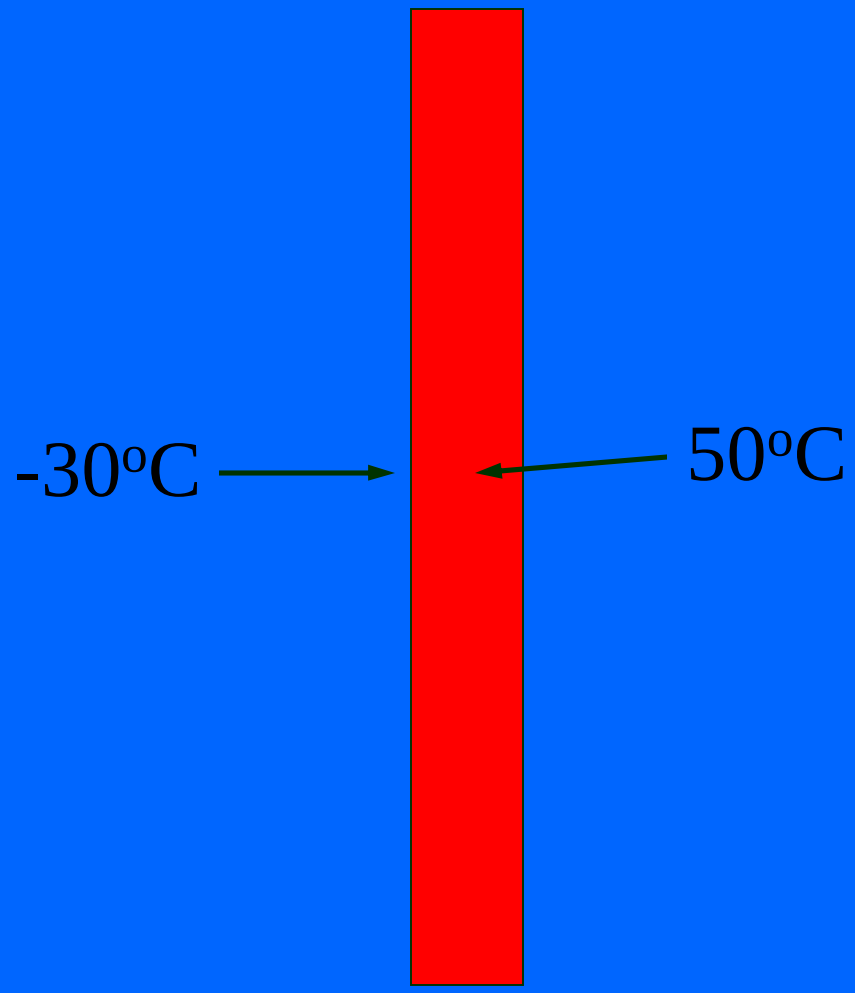
- Monitor structures and piping
  - Stress Levels
  - Corrosion: chemical and biological
- Monitor fluid composition
  - Can reduce the effects of corrosion with more information on fluid composition
- Wireless communication can be used for the above

Novel Technologies



Thermal Issues to be Addressed

- Thermal gradient can be 80°C
  - This can be over a very small thickness (cm's)
- Leads to very large thermally induced stresses



Composites

- Composite piping can be manufactured to have a zero net thermal expansion coefficient
  - Decrease/Eliminate thermal stresses
- Corrosion resistant is much greater than steel
- Can easily be embedded with smart materials

Composites

- Can implement Functionally Gradable Materials to better control the thermal gradient
  - Grade through-the-thickness thermal conductivity

Lasers

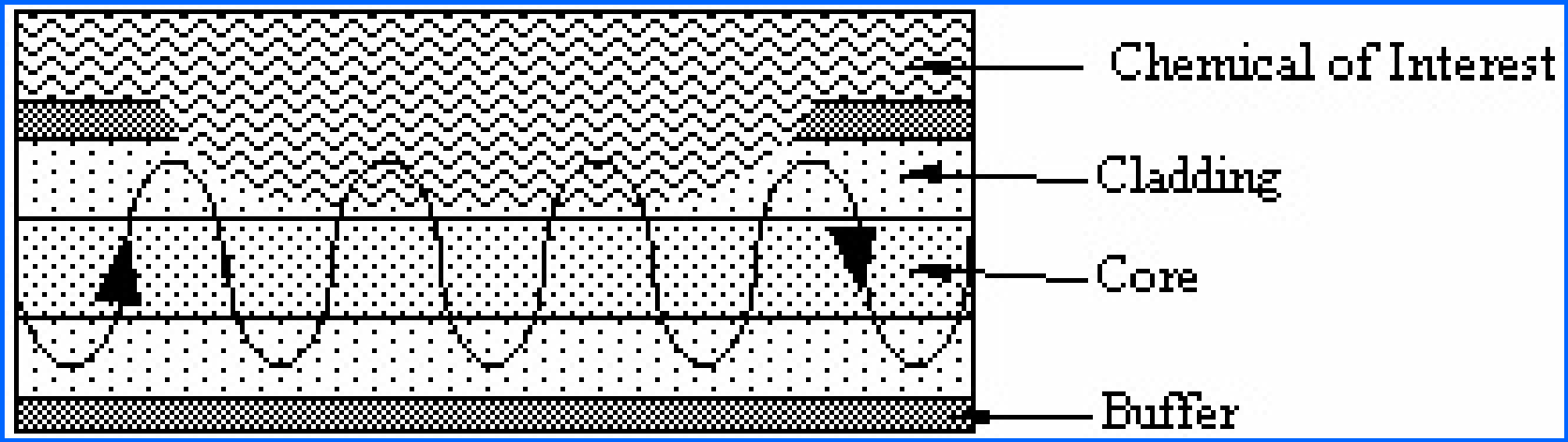
- Can implement Laser Doppler Vibrometer
  - Non-contacting measurement technique
- Can detect weak points in the structure
  - Composites
    - Delaminations
    - Matrix Cracking
  - Steel
    - Cracks
    - Corrosion

Smart Monitoring and Control

- Real-time continuous data
  - Stresses
  - Chemical compositions
- Measure dynamic response of the system
  - Can indicate if weaknesses are present
- Can be done with the use of fiber optics or piezoelectrics
  - Magnetostrictives can be implemented but size of the elements would limit their use
- Respond in real time to control the system

Fiber Optic Sensors: Chemical Composition Monitoring

- Very effective at measuring the chemical composition of fluids
  - This will allow for real-time continuous monitoring

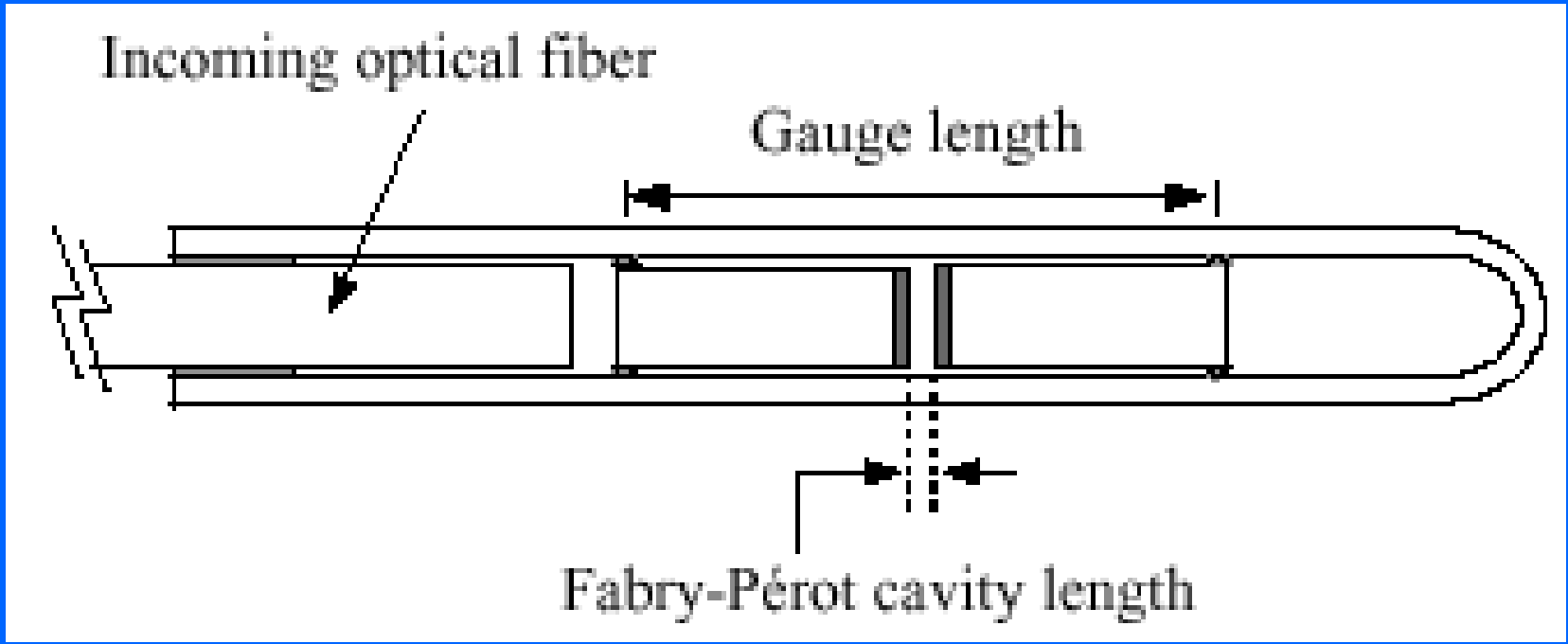


Fiber Optic Sensors: Strain Monitoring

- Large temperature changes are present which lead to high thermal stresses
- Can implement sensors to measure the total strain in the material or limit it to only mechanical loading
- Implement Fabry-Perot interferometers
  - Non-compensating (Measure total stress)
  - Self-compensating (Measure only mechanical stress)

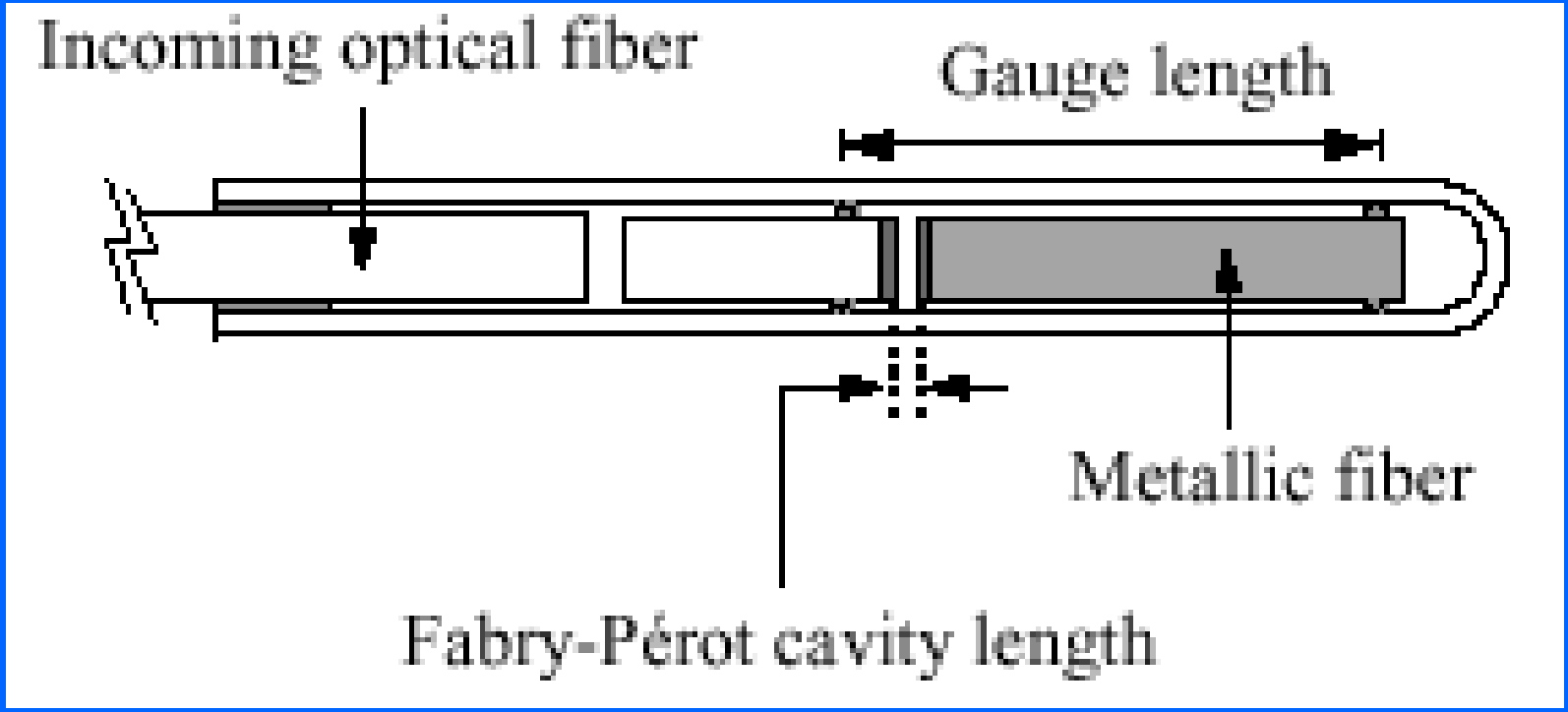
Fiber Optic Sensors: Strain Monitoring

- Non-Compensating



Fiber Optic Sensors: Strain Monitoring

- Self compensating



Piezoelectric Materials

- Can be embedded into composite components to measure and control the system
  - Can be operated with active control to respond only when required
    - Influence on dynamic characteristics limited
- Current systems use the addition of mass which greatly influences the dynamic response
  - May not be designed for

Needs for Remote Monitoring

- Locally located system to record the information
- Headquarter to monitor and interpret the results
- This will require wireless communication

Conclusion

- The need for monitoring of offshore systems is an issue now
  - Will allow for smarter and more knowledgeable designs
- Many different and versatile techniques are available
- This is a MULTIDICIPLANARY PROBLEM
  - Requires many fields of engineering and science to work together

Questions