#### RADIOTRACING TOOLS FOR ON-LINE MEASUREMENT



#### KEY PRODUCTS:



RNT/TLA FOR WEAR INVESTIGATIONS



D-LUBE FOR FUEL DILUTION



C-LUBE FOR ENGINE OIL CONSUMPTION

**AIR-X FOR LUBRICANT AERATION** 



FLUID CONDITIONING AND TEST RIGS

#### BENEFITS OF RADIOTRACING TECHNIQUES:

- Real-time results
- Very high sensitivity
- Non intrusive
- No dismantling
- Reduced test durations





#### WHAT IS OIL AERATION ?

Unbound Air	Bound Air			
	Dissolved	Bubbles	Foam	
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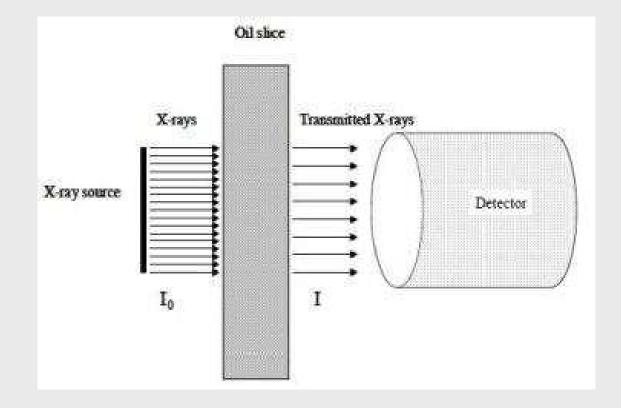
Figure 1-1 Illustration of the different interactions between air and oil

### **GAS CONTENT ISSUES:**

- Increased oil temperature and thermal breakdown of the oil
- Reduction of cooling effect due to inefficient heat transfer
- Reduced lubricants viscosity and retarded oil supply -> higher wear rates
- Cavitation in oil pumps and bearings (main and conrod bearings)
- Accelerated oil oxidation
- Lower bulk modulus -> erratic hydraulic operation (critical to lash adjusters, belt tensioners,...) -> loss of load and power, valvetrain failure, air-lock, etc.



#### BASED ON A DENSITY MEASUREMENT (2)



## NaI(Tl) scintillators



The loss of intensity of an X-ray beam is given by the law:

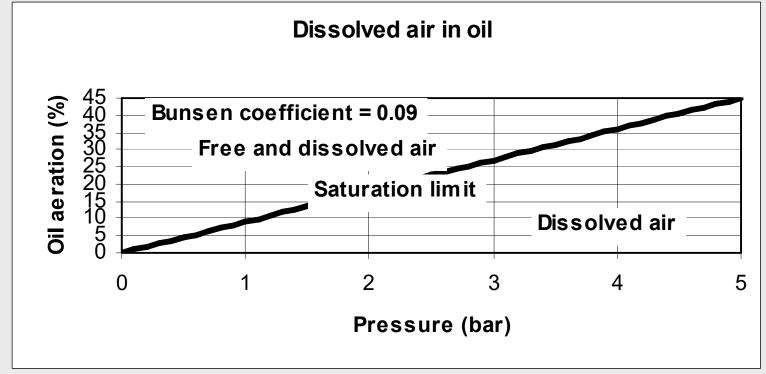
 $I=I_0 e^{-\mu rx}$ 

I is the intensity of the transmitted beam (number of X-rays/s)
 I<sub>0</sub> is the intensity of the source beam (number of X-rays/s)
 μ is the absorption coefficient depending on X-ray energy and material (cm<sup>2</sup>/g)
 r is the mass density (g/cm<sup>3</sup>)
 x is the thickness of crossed material (cm)



#### DISSOLVED AIR FRACTION (3)

## **Dissolved Air - Henry-Dalton's Law**



Volume of disolved gas in a liquid is given <u>at equilibrium</u> by:

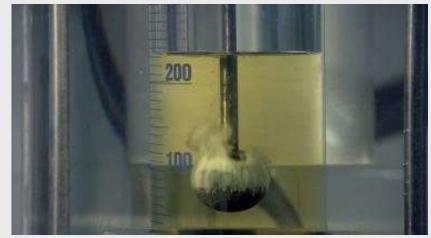
$$V_{gas} = c V_{liq} (P + P_{atm}) / P_{atm}$$

 $V_{gas}$  = dissolved volume of gas under normal conditions (20° C, 101.3 kPa)  $V_{liq}$  = volume of liquid under normal conditions P = relative pressure  $P_{atm}$  = normal atmospheric pressure c = Bunsen coefficient (typically 0,08 to 0,1 for lubs in engine) at given T°



## AIR- X : A REFERENCE TOOL FOR MONITORING OIL AERATION

- On-line results with **response time from 1 sec to several minutes**
- Measuring range: 0-100% in term of gas content
- Accuracy :
  - $\pm$  0,5 % for 10s acquisition time
  - $\pm$  0,1 % for 60s acquisition time
- Easy calibration
- User friendly and quick set up
- Suitable to use with any lubricant
- No need to label the oil



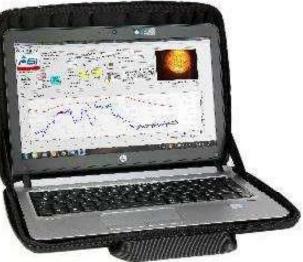
- Sample point from any mechanical system (engine gallery, oil pan, gear boxes, pressurized pipes, oil tank...)
- Use of an exempted X-Ray source
- Real-time visualization of oil flow in the measuring chamber
- Not a black box: access to measurement parameters for in-depth analysis



#### AIR-X SENSOR CLOSE VIEW (5)



- X-ray source
- Detector
- MCA
- Analog I/O
- Dedicated software
- Live flow visualization



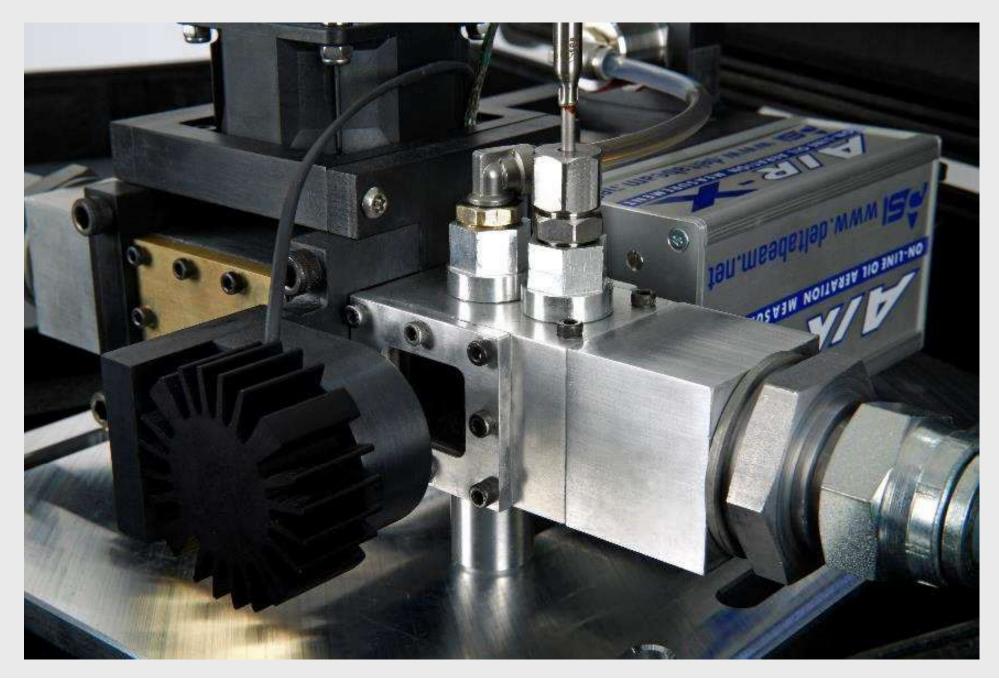


#### AIR-X SENSOR CLOSE VIEW (6)





#### AIR-X SENSOR CLOSER VIEW (7)





#### AIR-X SENSOR CLOSE VIEW (8)



STANDARD AIR-X AND COMPACT AIR-X (9)

## **TWO VERSIONS AVAILABLE:**

#### Standard Air-X



Compact Air-X



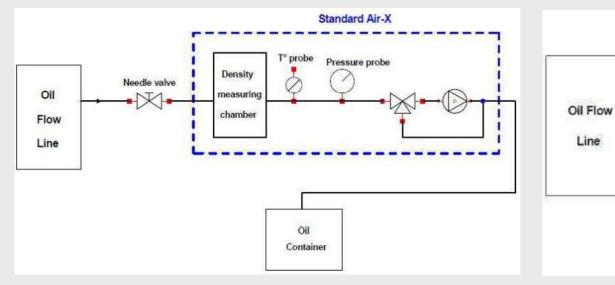
- With internal pump to sample fluid from oil tank or oil pan
- Lightweight and portable version for dyno, on-board, dry sump and tilt rig application

Similar sensor, electronic, software and computer -> same performances

STANDARD AIR-X AND COMPACT AIR-X (10)

## **TWO VERSIONS AVAILABLE:**

#### Standard Air-X



- By-pass for the pump
- Possibility to measure the dissolved air fraction by dropping down the pressure

 Suitable for higher oil flow measurement

Needle valve

**Compact Air-X** 

Compact Air-X

T° probe

Density

measuring

chamber

Oil

Container

Pressure probe

 Can be placed inline in lubrication system



#### SAMPLING SYSTEM FOR COMPACT AIR-X



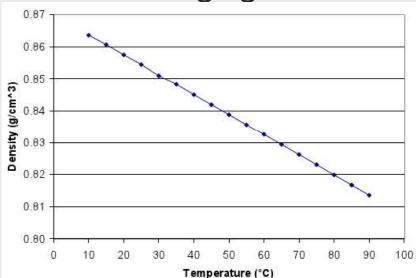




#### HOW TO CALIBRATE AIR-X (11)

## **CALIBRATION:**

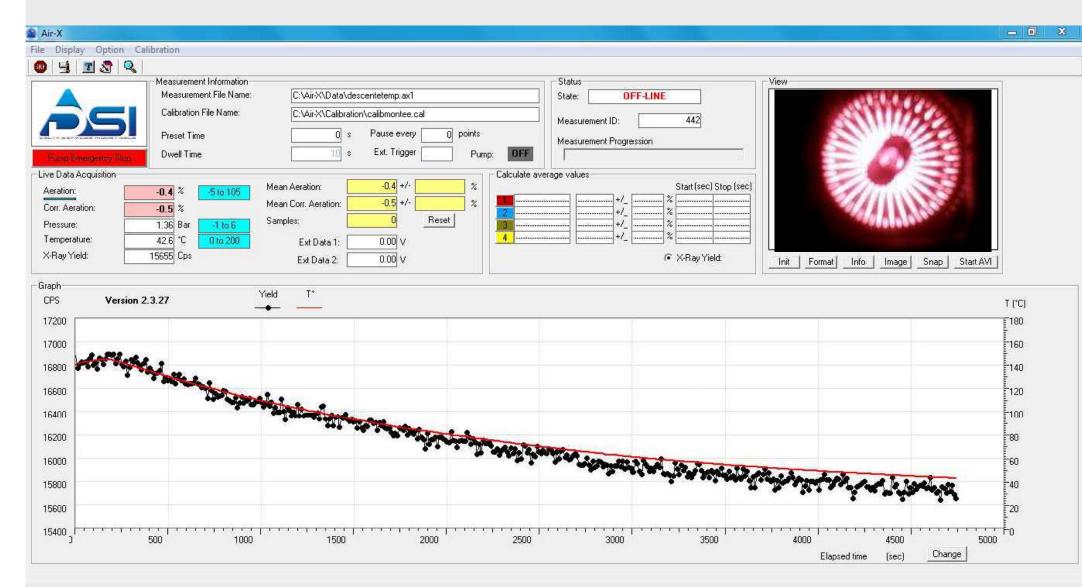
- 100% air: empty measurement chamber (1 minute)
- 0 % air: "temperature calibration"
  - > Oil density decreases when oil temperature increases
  - Depends on oil formulation
  - Calibration routine (1.5 hr)
  - > Has to be done once per oil
- 0% air: re-calibration (1 minute)
  - To compensate for oil aging and contamination





#### OIL AERATION MEASUREMENT WITH AIR-X (12)

#### CALIBRATION: 0% TO BE PERFORMED FOR EACH OIL REFERENCE



# OIL AERATION MEASUREMENT WITH AIR-X (13)

#### CALIBRATION: 0% TO BE PERFORMED FOR EACH OIL REFERENCE

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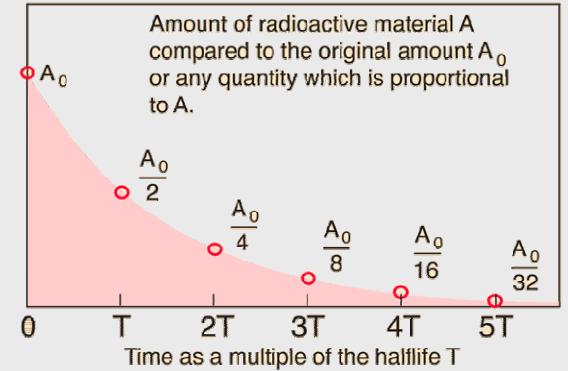
## OIL AERATION MEASUREMENT WITH AIR-X (14)

#### CALIBRATION: 0% TO BE PERFORMED FOR EACH OIL REFERENCE

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- Sealed X-ray source of Cd-109
- Half-life = 462 days
- To maintain accuracy and short response time:
  - -> Source replacement every 2 years
  - -> Supply of a new X-ray source (incl. disposal of the old source) + source certificate + holder
  - = downtime of approx. 2 weeks





### OIL AERATION MEASUREMENT WITH AIR-X (16)

## Custom-made sensors:

- Compact measurement probe for complete integration in vehicule for on-road or on-track measurement
- Dual Air-X system for on-line measurement oil separator system efficiency







## Origin of entrained gas

- Underfilling or overfilling of oil pans
- Insufficient blow-by oil mist separation
- Ineffective design and positioning of oil intake and wash plate within oil pan
- Ineffective oil injection nozzles design
- Shorter rest time of lubricant within oil pan due to high flow rate / low oil level
- Acceleration and inclination of the mechanical system (driving in bends at high speed)
- Inappropriate oil formulation
- Outside air sucked into the system after inlet

## Air- X usages:

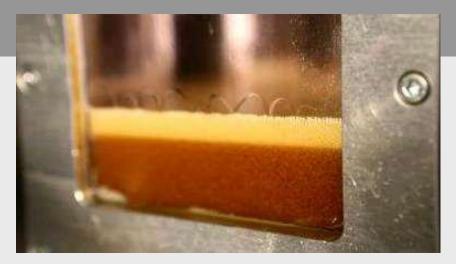
- Investigation of the root cause of foam and air entrainment problems
- Test of antifoam additives and lubricants properties
- Definition of maximum and minimum level of oil stick
- Optimization of lubrication circuit
- Incorporation of aeration data into analytical model
- Easy mapping of air content versus inclination or acceleration
- Monitoring entrained air in hydraulics installation

#### KEY PRODUCT N° 5A: FLUID CONDITIONING SYSTEMS WITH OIL AERATION GENERATOR



Fine bubbles and foams (mayonnaise) up to 20 % of aeration "Big" bubbles up to 80 % of aeration

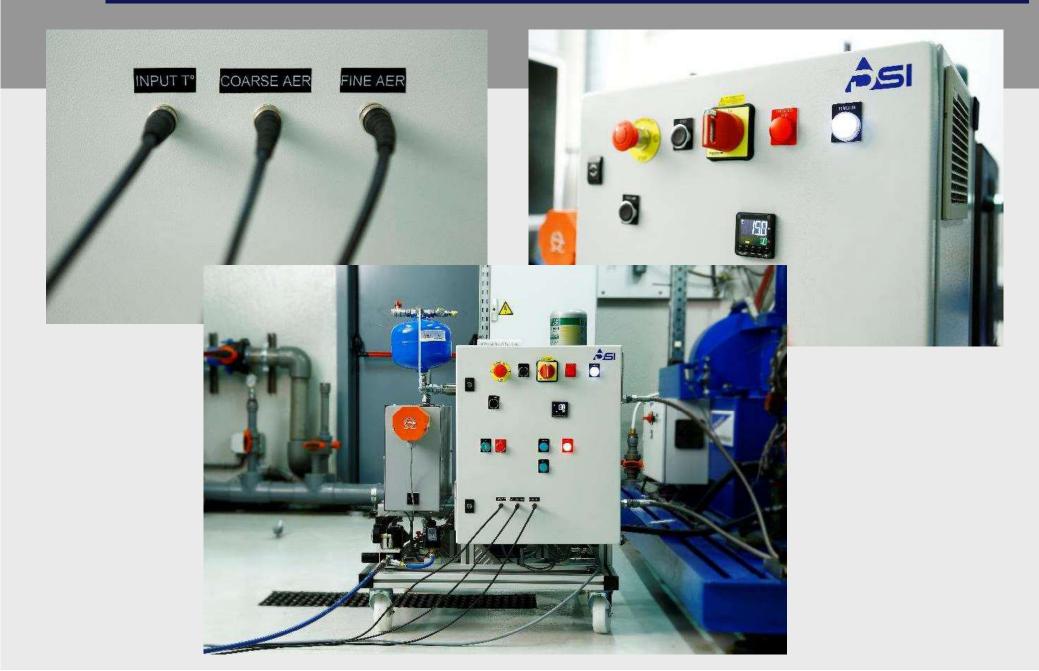
Adjustable oil flow, pressure, temperature and **aeration** 





 $\rightarrow$  Laboratory rigs to measure de-aeration efficiency of lubricants

#### KEY PRODUCT N° 5A: FLUID CONDITIONING SYSTEMS WITH OIL AERATION GENERATOR



#### KEY PRODUCT N° 5A: AIR-MIX SYSTEM FOR DEAERATION OIL TANK EFFICIENCY MONITORING (USED IN FORMULA 1)





