Diagnosis of Pneumatic Cylinders Using Acoustic Emission Methods

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Discourse on Dissertation thesis
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Institute of Machine and Industrial Design

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- Introduction
- Leak testing methods (LT)
- Analysis and evaluation of Previous study
- Current state solution of dissertation
- Future work
- Conclusion

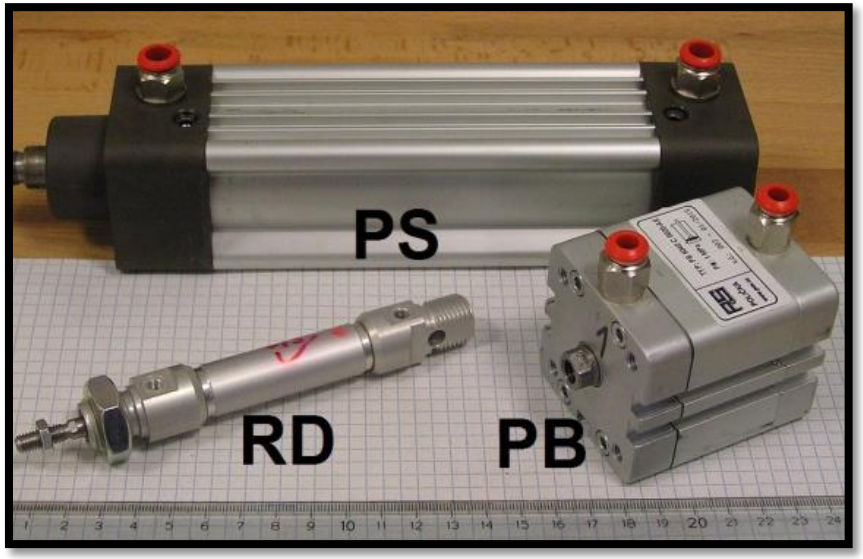
Introduction, problem and goal

The quality of pneumatic cylinder.

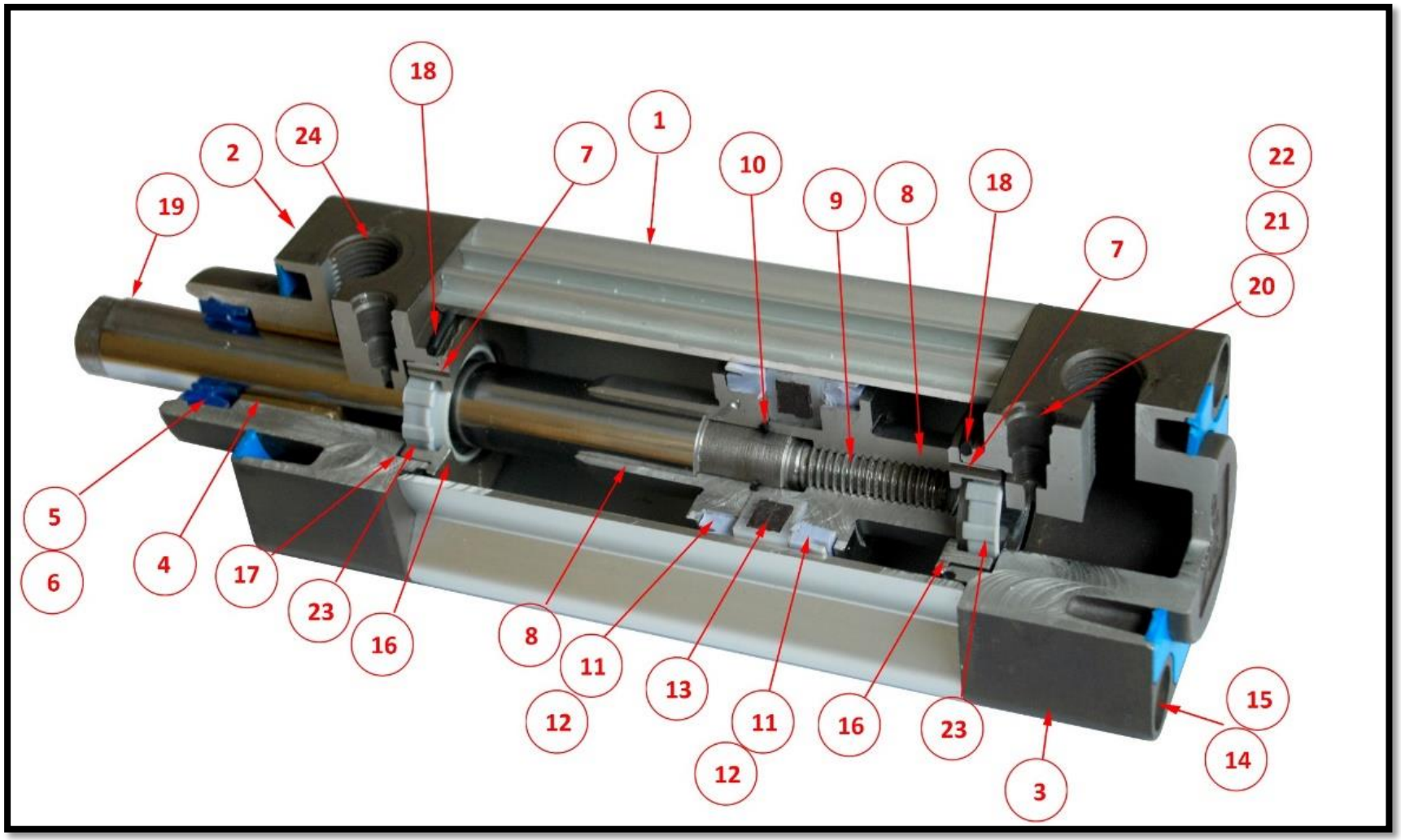
The function of pneumatic cylinder

The relationship between AE and defect.

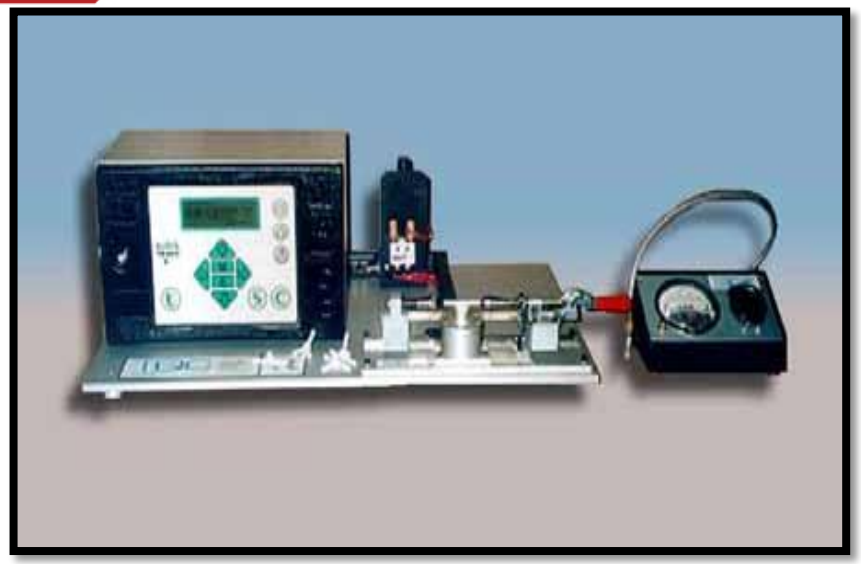
New parameters of AE



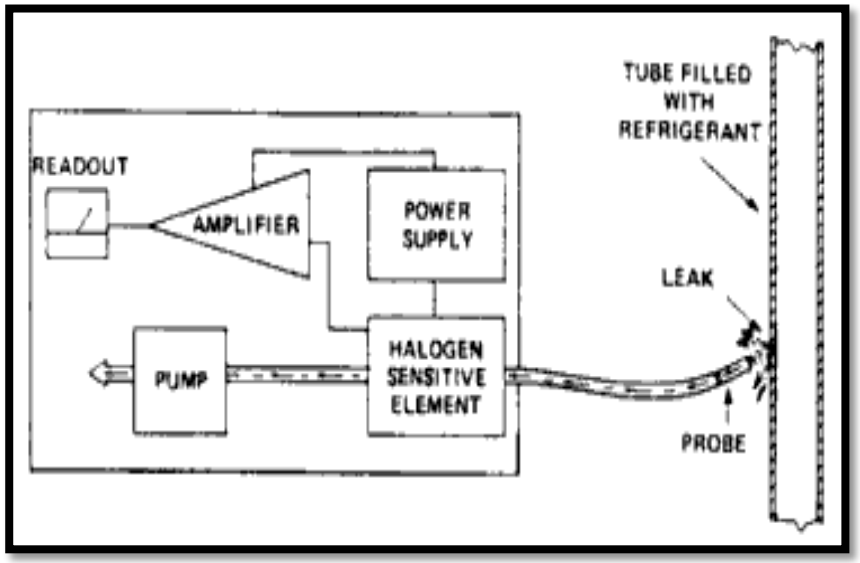
Specification of pneumatic cylinders



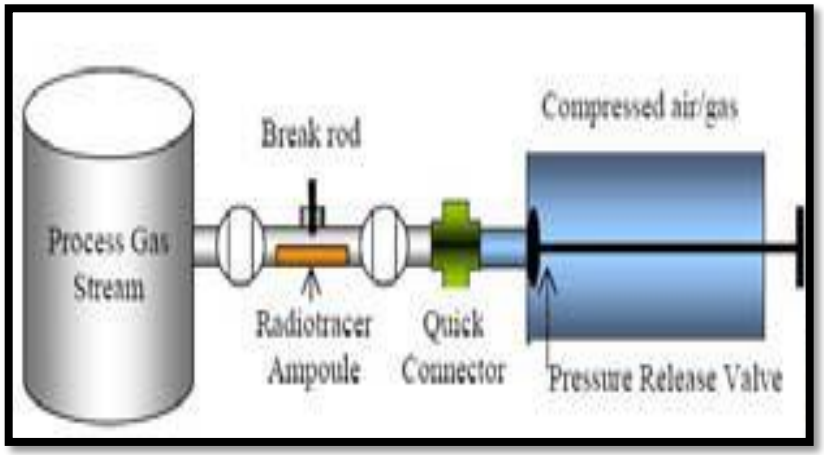
Leak testing methods (LT)



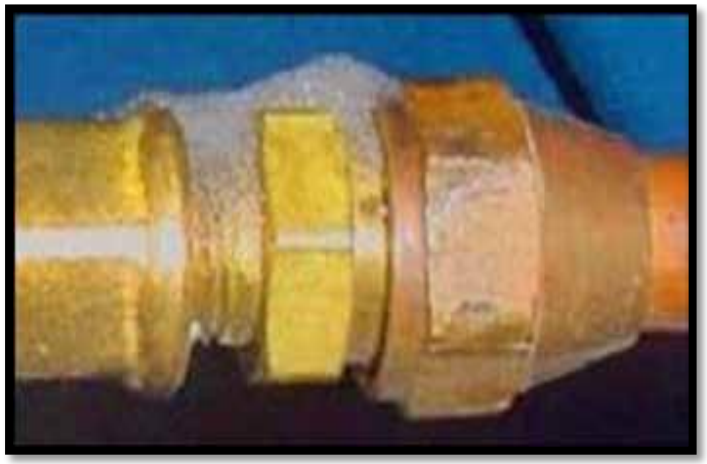
Testing by means of pressure Leak testing small medical tubing connection [1]



Test by detection of halogens[1]



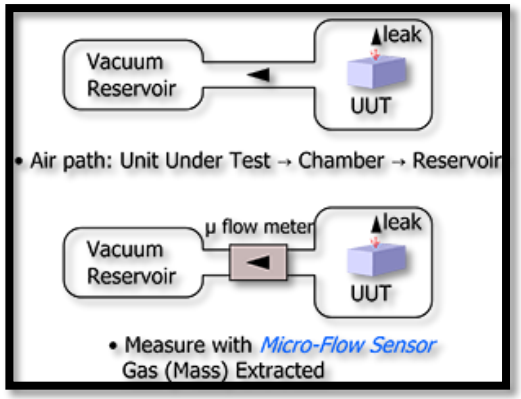
Radioactive tracers Gaseous radiotracer injector[1]



Foam film and bubbles to detect gas[1]

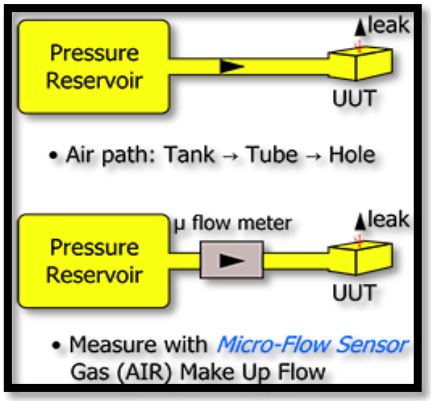
Leak testing methods (LT)

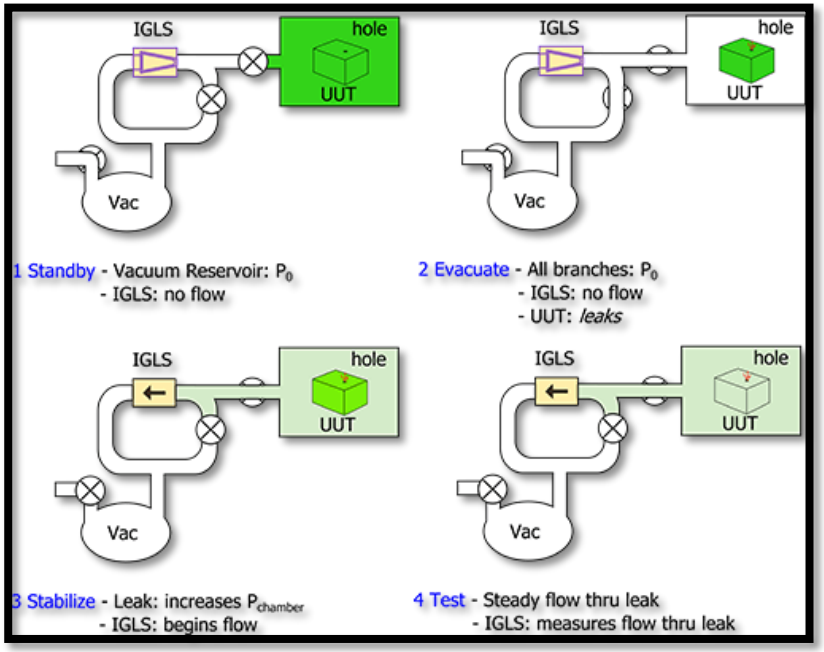
ATC micro- flow sensor to measure the leak, pressure test



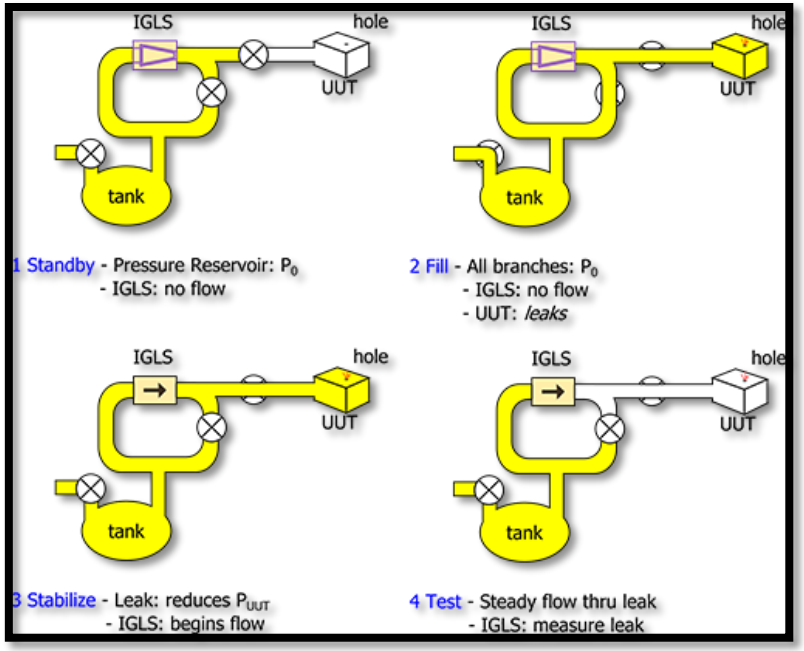
(IGLS), Intelligent Gas Flow Sensor

(ATC), Advanced Test Concepts





Method of operation– vacuum test[2]

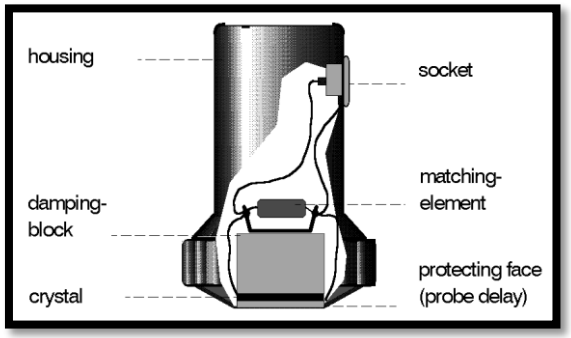


Method of operation– pressure test[2]

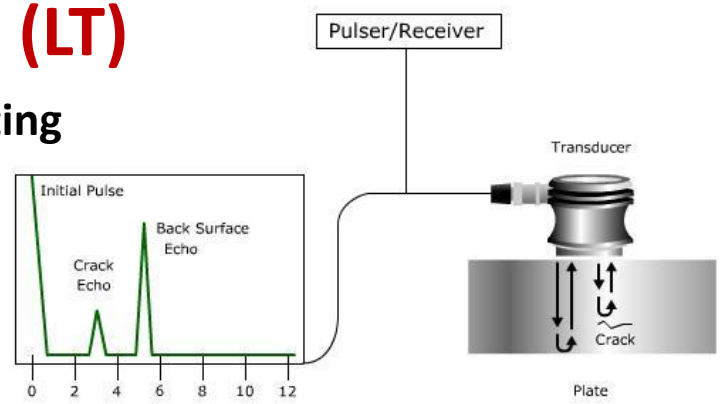
http://atcinc.net/how-it-works/

Leak testing methods (LT)

Ultrasonic testing



Sensor UT[3]



Ultrasonic Testing (UT) uses high frequency sound energy

http://ultrasonicinfo.blogspot.cz/

Acoustic emission (AE)

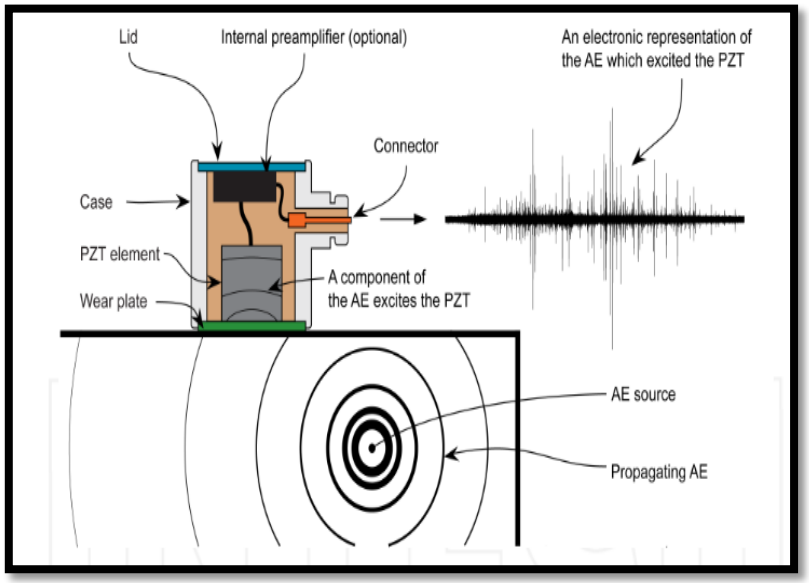
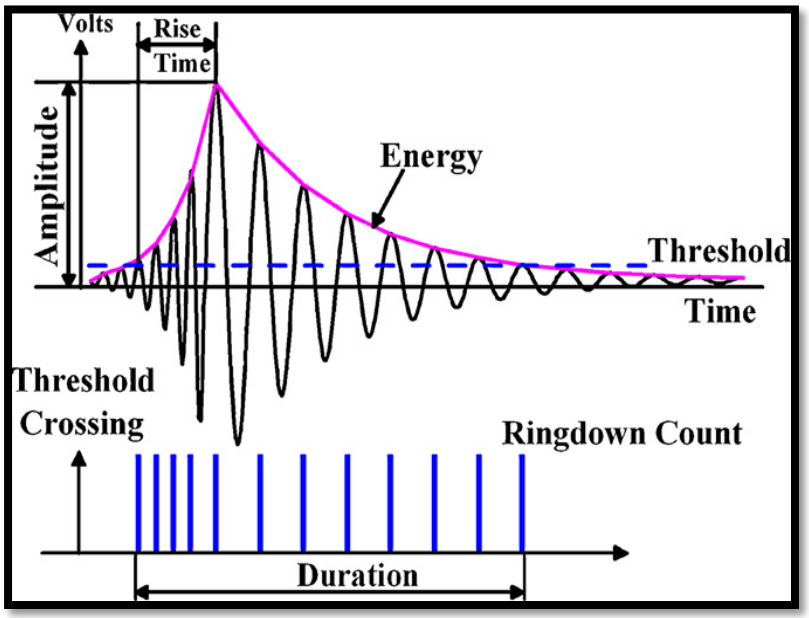


Illustration of a typical resonant piezoelectric AE transducer and how an AE is converted into an electric representation[4]



Method of extracting AE parameters [5]

Previous studies

- A study on correlation of AE signals from different AE sensors in valve leakage rate[6]

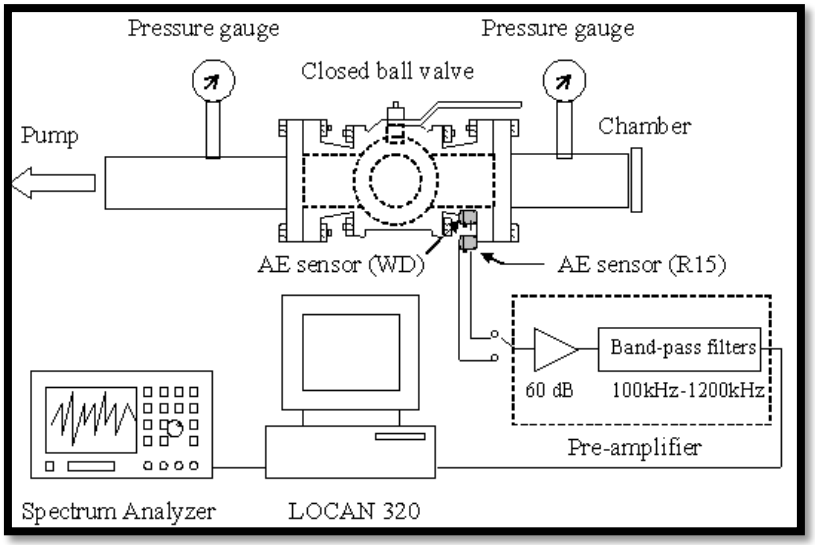
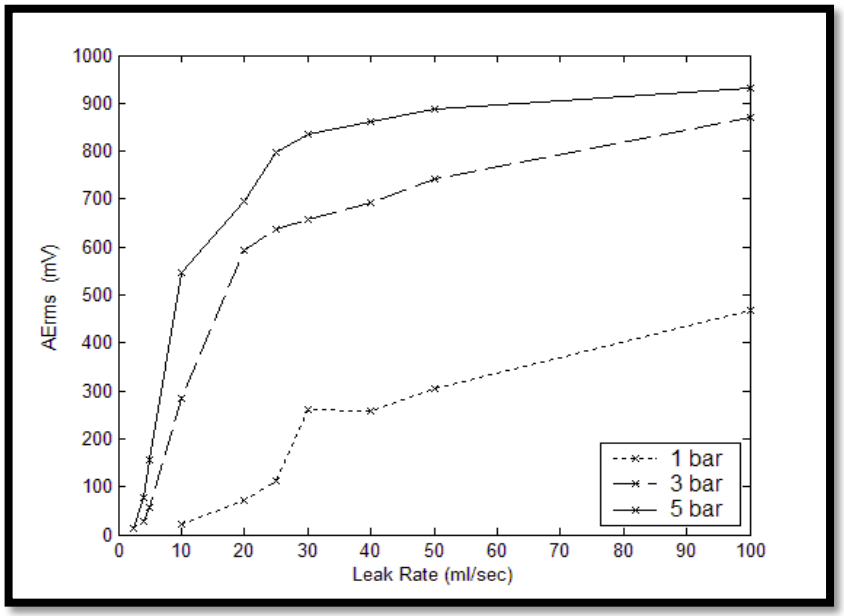
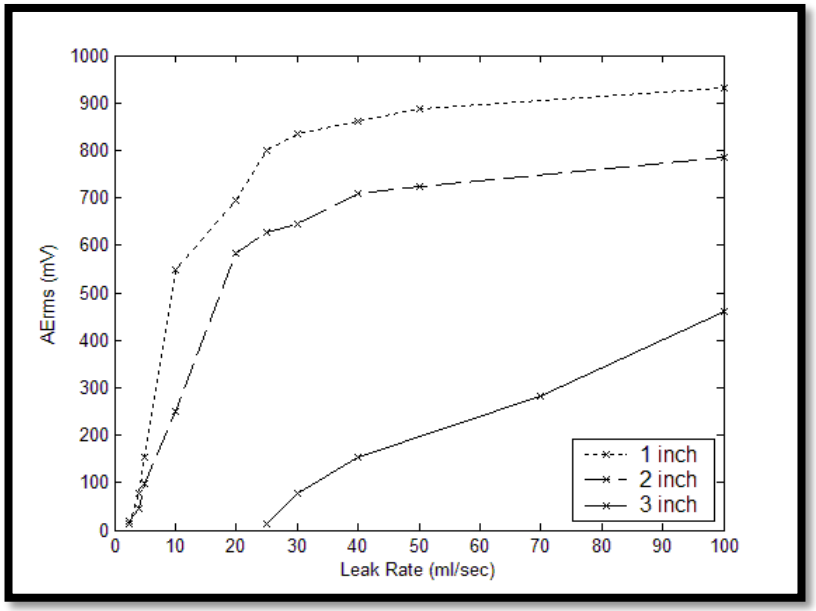


Diagram of experimental set-up



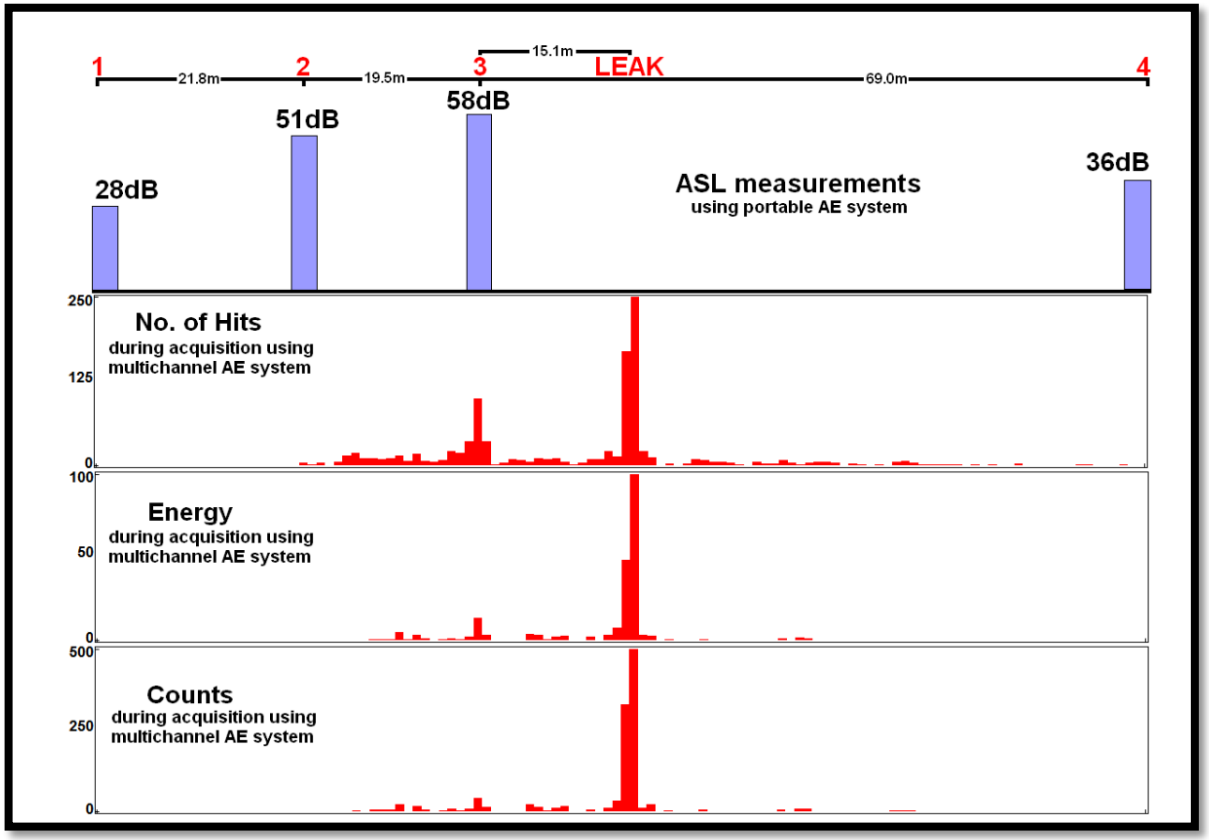
Relationship between AErms and leakage rates of 1 inch ball valve at different pressures.



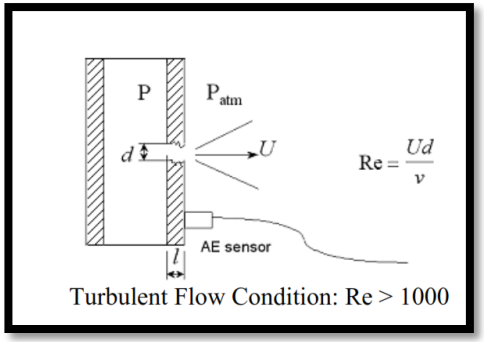
Relationship between AErms and leakage rates of different valve sizes at P = 5 bar

Previous studies

- Acoustic emission leak detection of liquid filled buried pipeline[7]



ASL vs linear location indicating the leak point



Leaking flow features

U Mean fluid velocity through orifice

d Mean orifice diameter

l Orifice length

v Kinematic viscosity of fluid

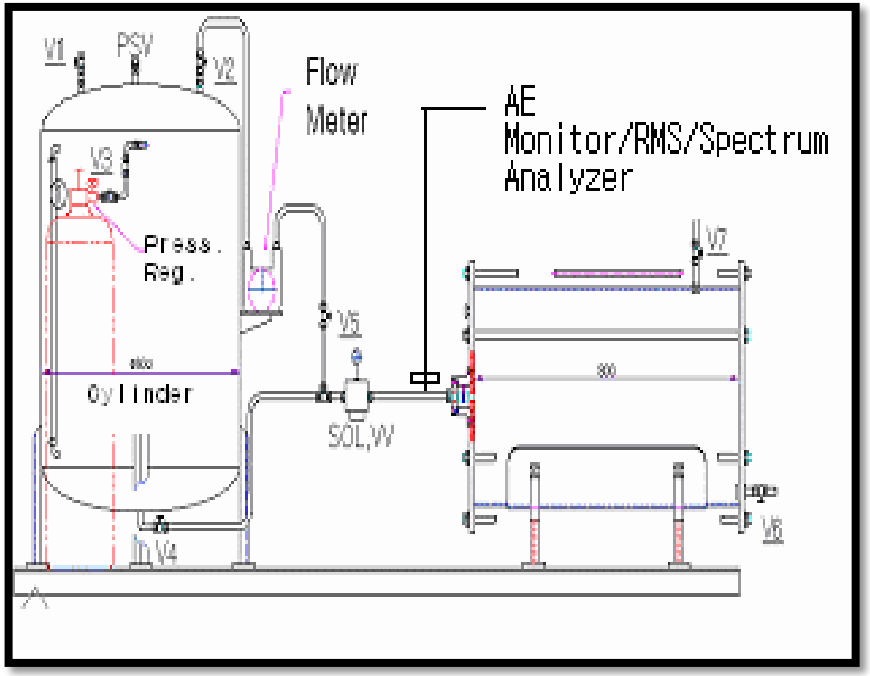
P Pressure inside the pipeline

$\mathbf{P_{atm}}$ Atmospheric Pressure

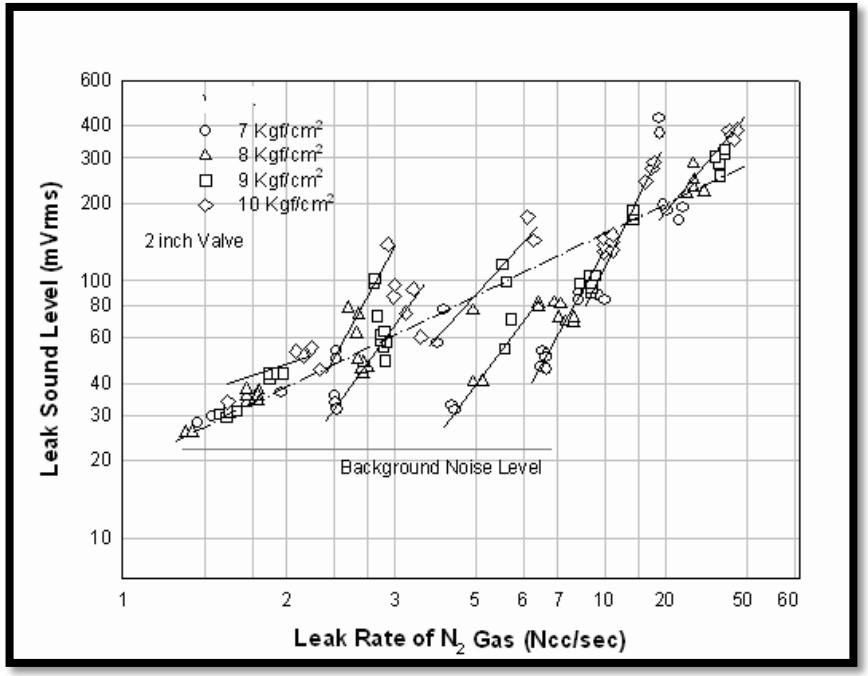
Re Reynolds number

Previous studies

- Field Application Study for Leak Detection Using Acoustic Emission Technology[8]



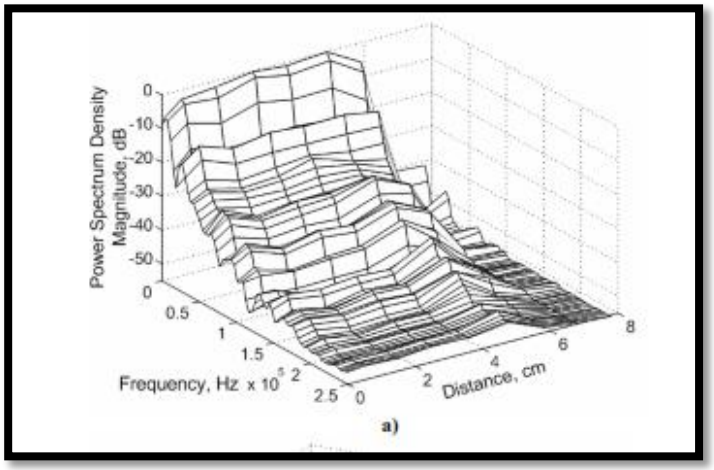
Experimental set-up for leak detection

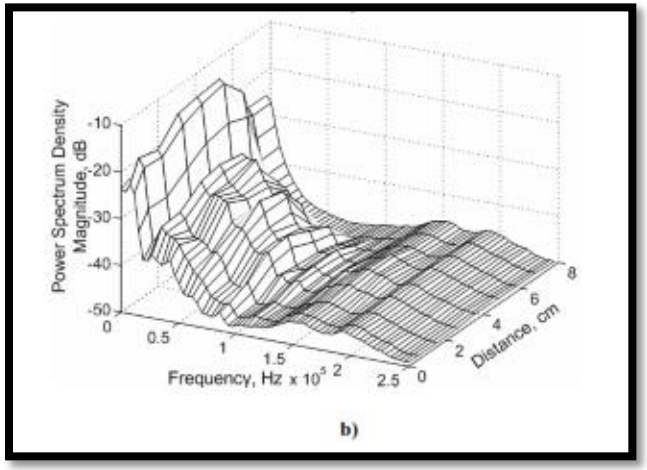


Plot of leak rate vs. acoustic signal amplitude detected by S1 sensor for four different pressure levels

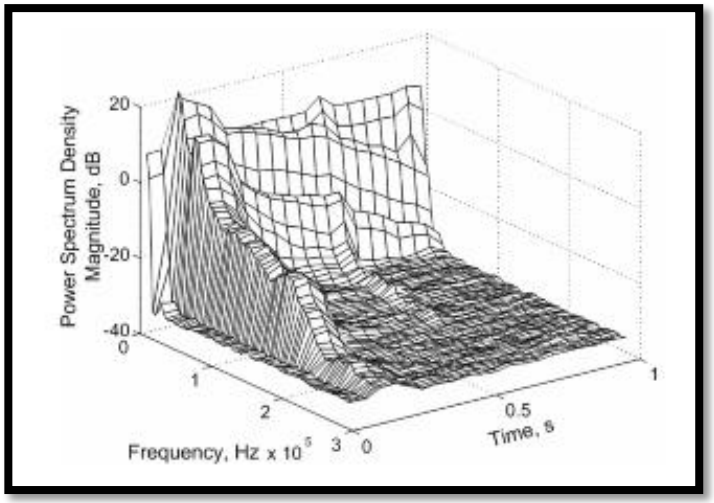
Previous studies

- Investigation of high frequency vibrations of pneumatic cylinders[9]

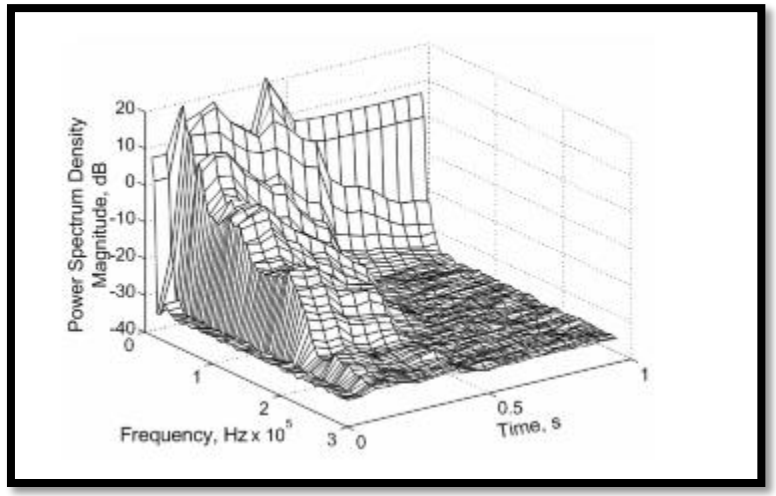




Power spectrum densities of the HFV at various measurement points: a) HFV are measured on pneumatic cylinder housing; b) HFV are measured inside pneumatic



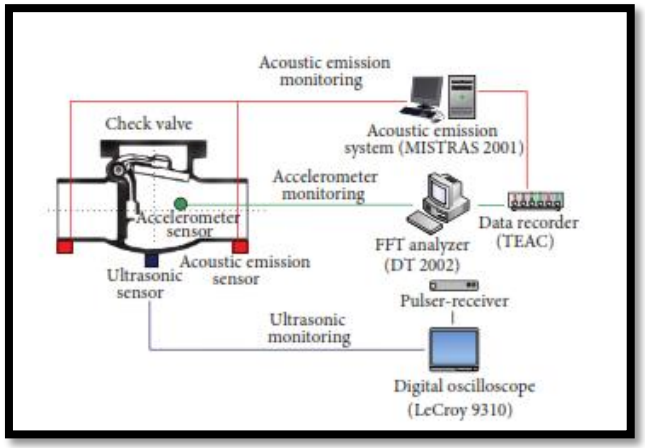
Power spectrum density of the HFV of the new pneumatic



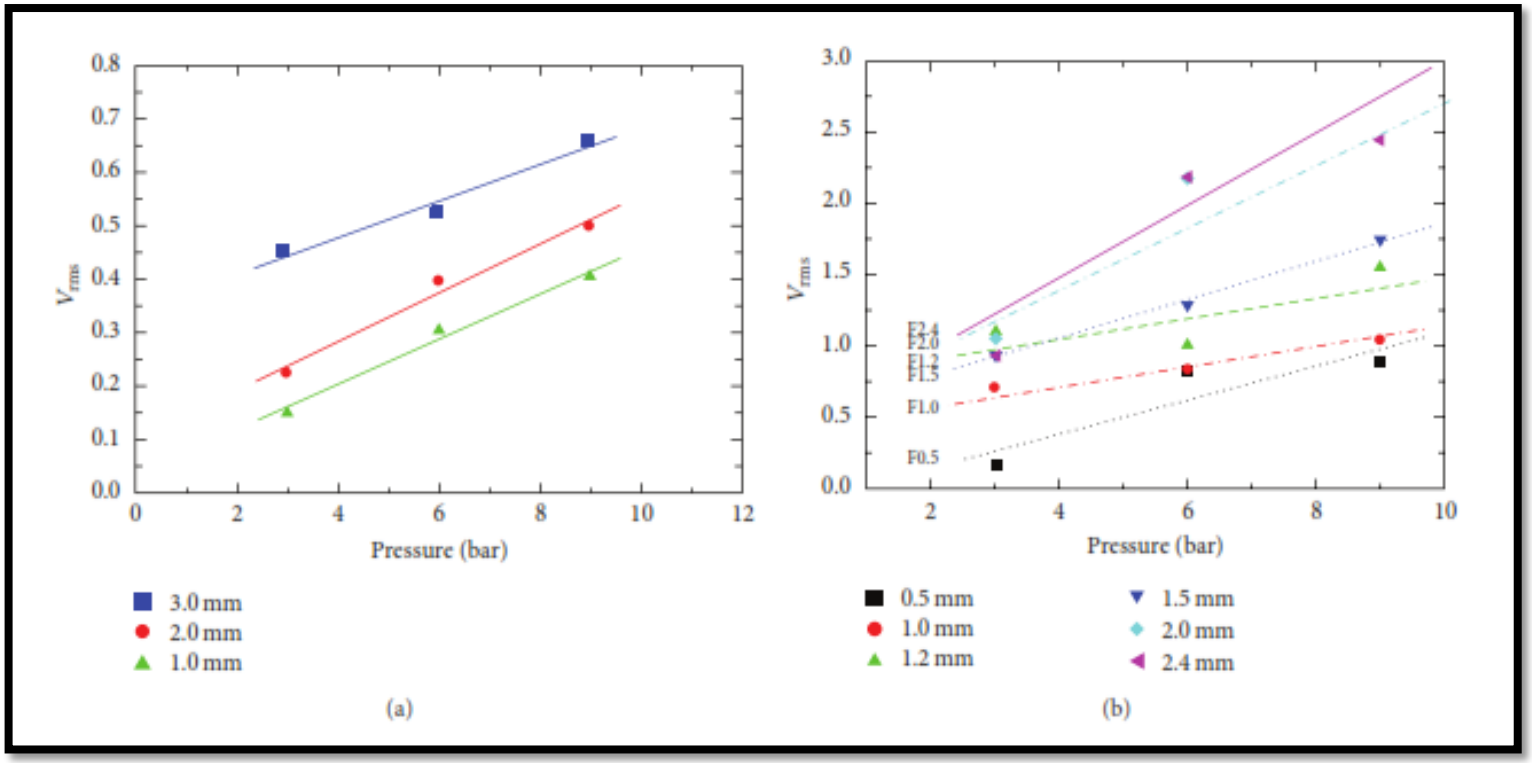
Power spectrum density of the HFV in the worn pneumatic cylinder

Previous studies

- Nondestructive Detection of Valves Using Acoustic Emission Technique[10]



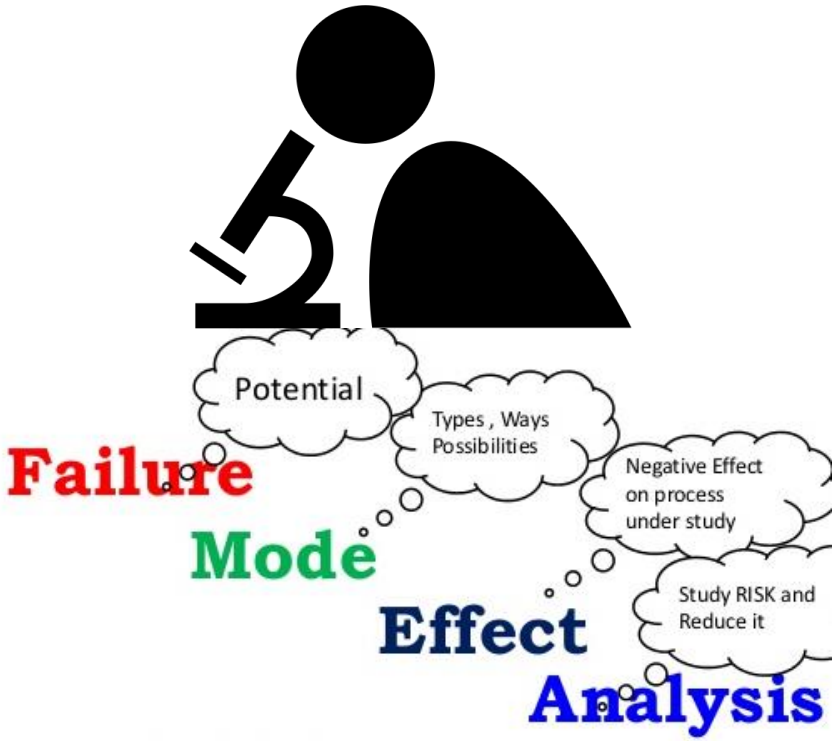
Schematic diagram for condition monitoring test of the check valve



RMS values of the acoustic signals: (a) disk wear and (b) foreign objects

Analysis and evaluation of Previous studies

1. Coefficients S, D.
2. Ultrasonic.
3. Acoustic emission.
4. Internal leak modelling.
5. AE activities and the leak.
6. Typical AE and the defect location.
7. The most important parameters.



Analysis and evaluation of references

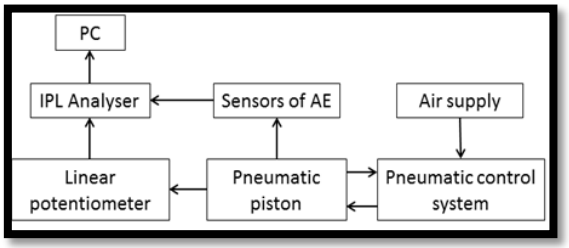
The problems that we have faced in the work (disadvantages)

- Signal in same undamaged cylinders.
- Sensor fastener
- Noise in the signal.

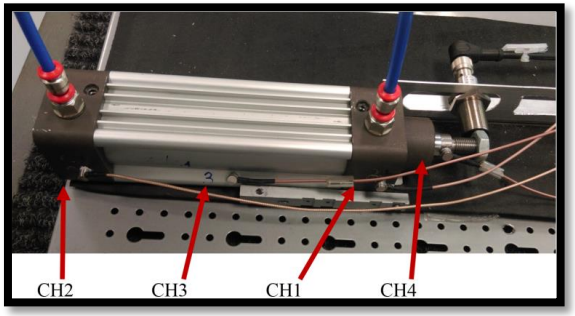
Hypotheses

- Changing of signal according to the movement of piston.
- Relation between AE and the leak .
- Allowance of leakage value is 6 Pa/s.

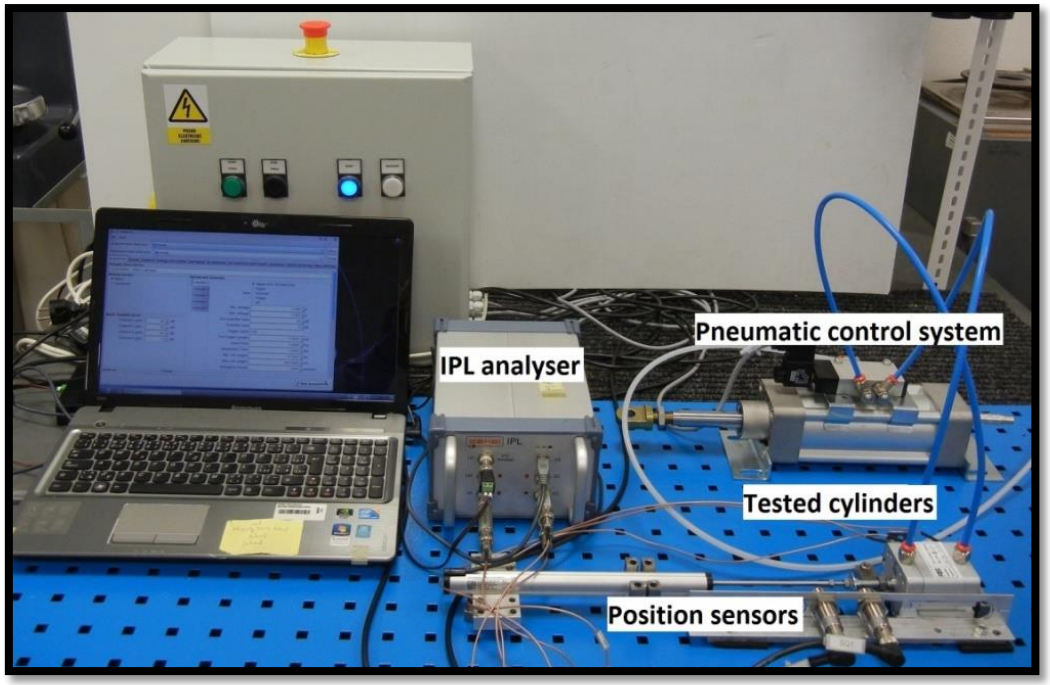
Current state solution dissertation



Schema of the experimental stand for testing of pneumatic cylinders

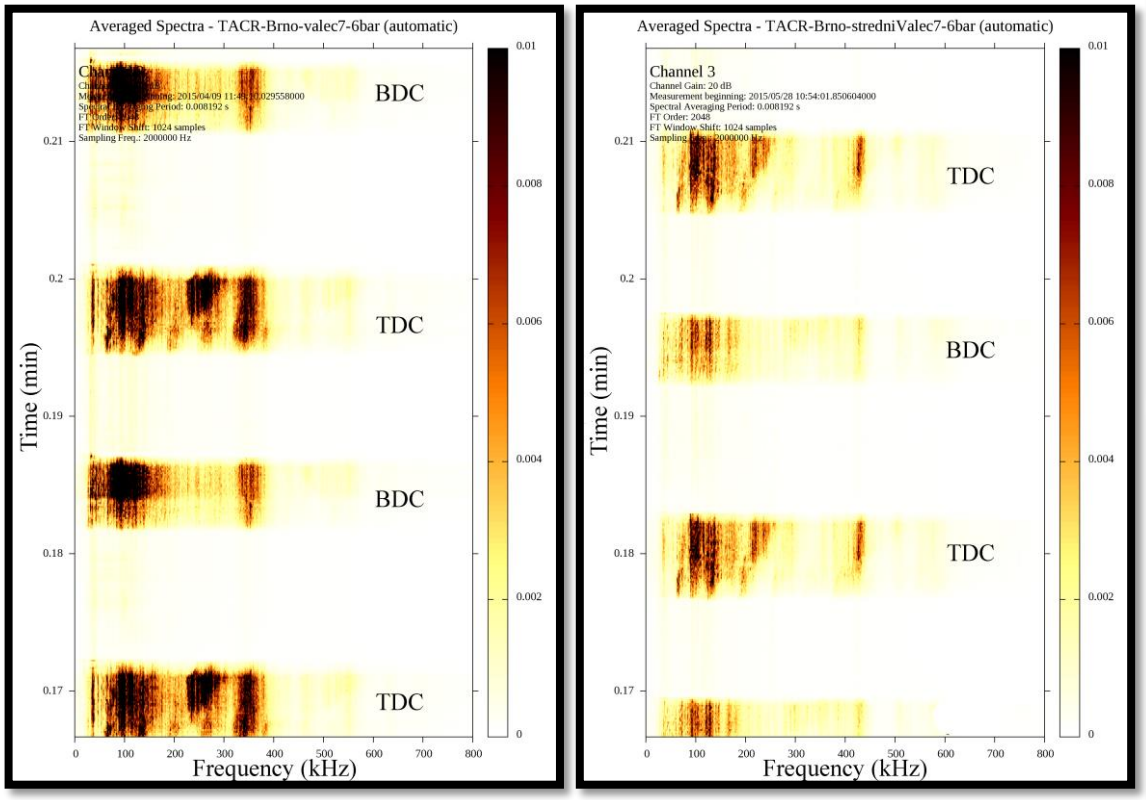


Position of AE sensors on the pneumatic cylinder (PS).



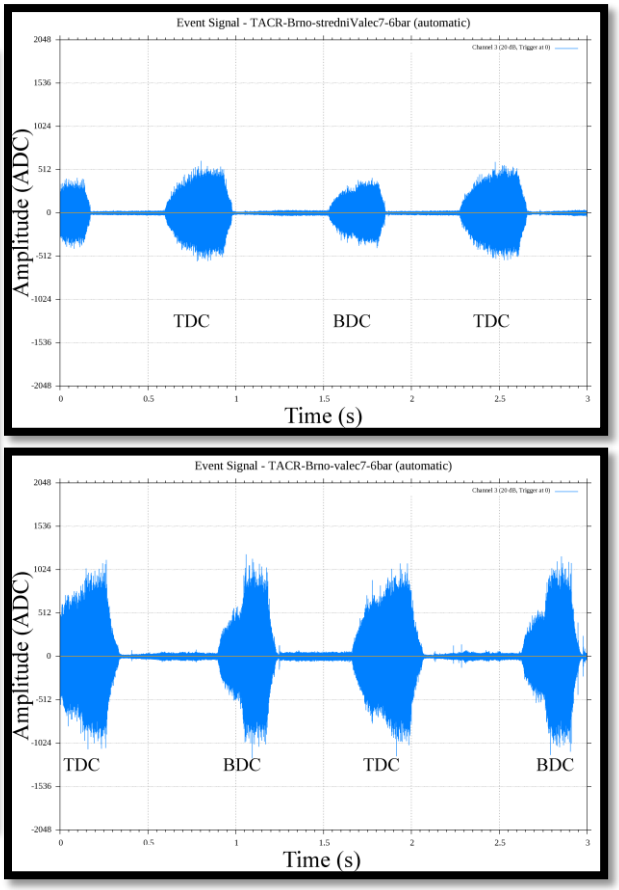
Assembly of experimental equipment

Current state solution of dissertation



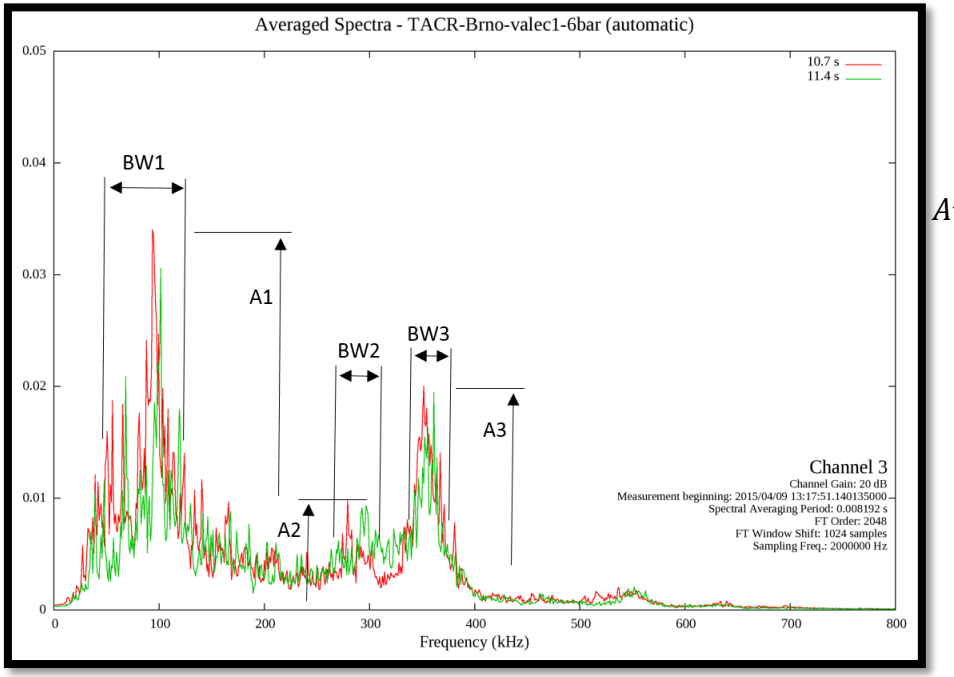
Spectral analysis in particular time - differences between signal spectrums obtained from cylinder without defect (a) and with defect (b).

TDC: when the piston impacts head cap cushion
BDC: when the piston impacts rear cap cushion



Comparison of the waveforms for the undamaged and damaged cylinder “PS” for 3 s

Current state solution of dissertation



$$Avg = \frac{dBW_1 + dBW_2 + dBW_3}{3} + 1000 * \frac{dA_1 + dA_2 + dA_3}{3}$$

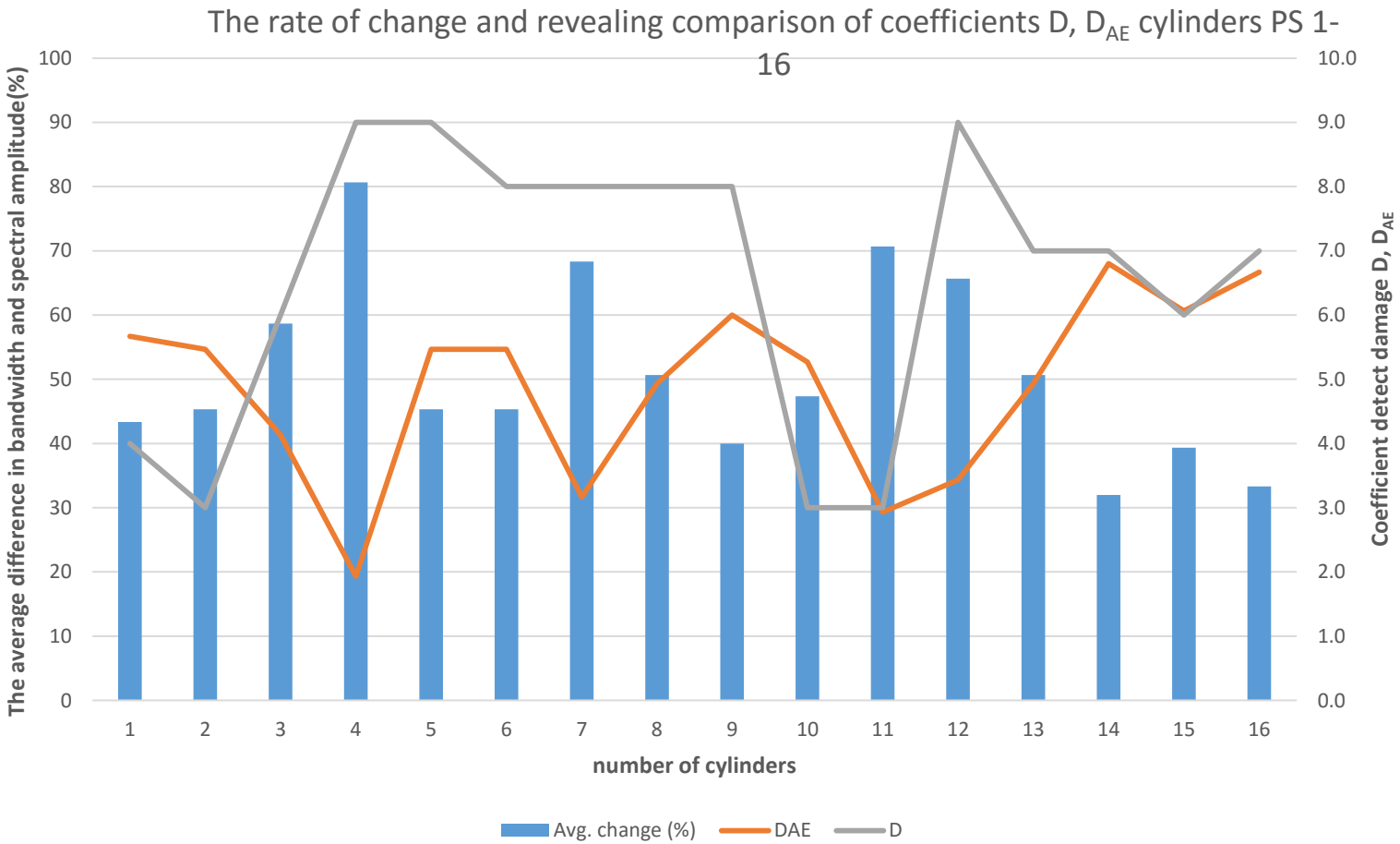
$$D_{AE} = \frac{100 - 2 * Avg}{10}$$

$$maxAvg = 50 \; minAvg = 0$$

Sample determination bandwidth max. Amplitude at undamaged cylinders PS

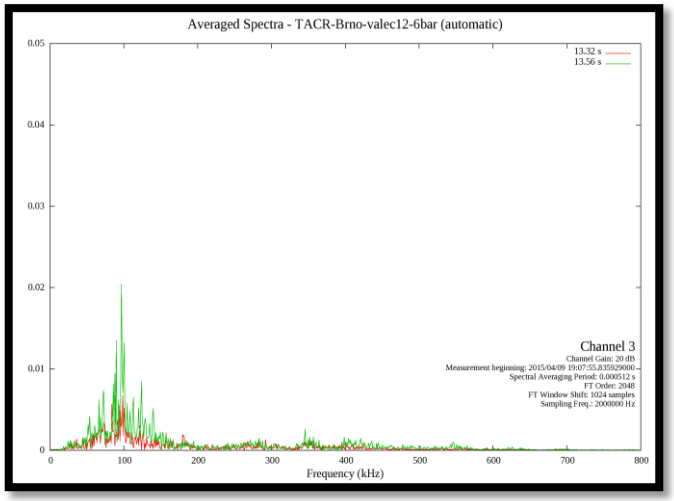
No. Cylinder	Type of defect	Description of the defect	Change BW (%)	Amplitude change (%)	The average change (%)	S1	S2	D	D_{AE}
4	BP 03	Missing O-ring on the piston rod	28	12,3	40,3	3	10	9	1,9
	BP 04					3	10	9	
12	TP 07	Cutting the O-ring on the piston rod	27,6	5,1	32,8	3	10	9	3,4
	TP 08					3	10	9	
14	M 03	Loosening 4 screws under the piston	9,3	6,6	16	3	10	7	6,8

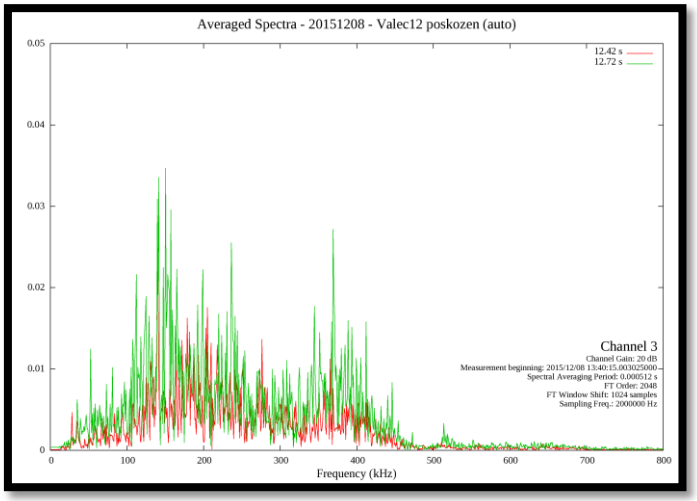
Current state solution of dissertation



Rate changes caused by that damage coefficient and detection (DAE)

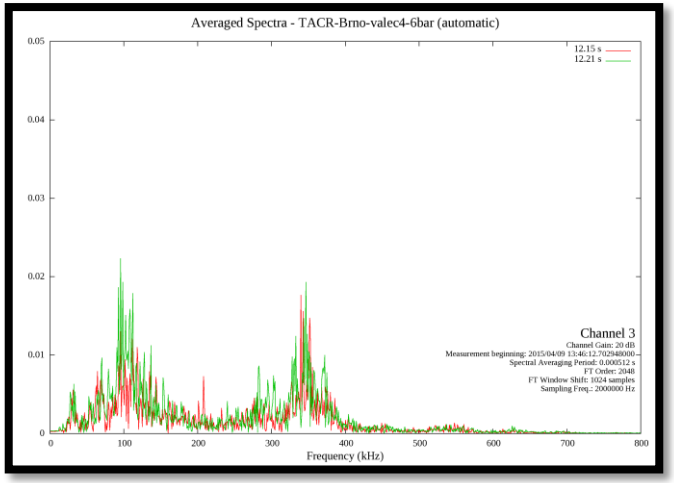
Current state solution of dissertation

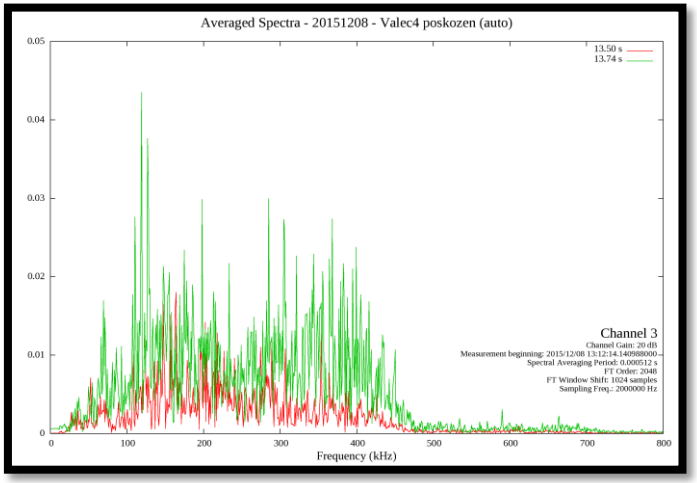




Signal spectrum of cylinder No. 12

Amplitude





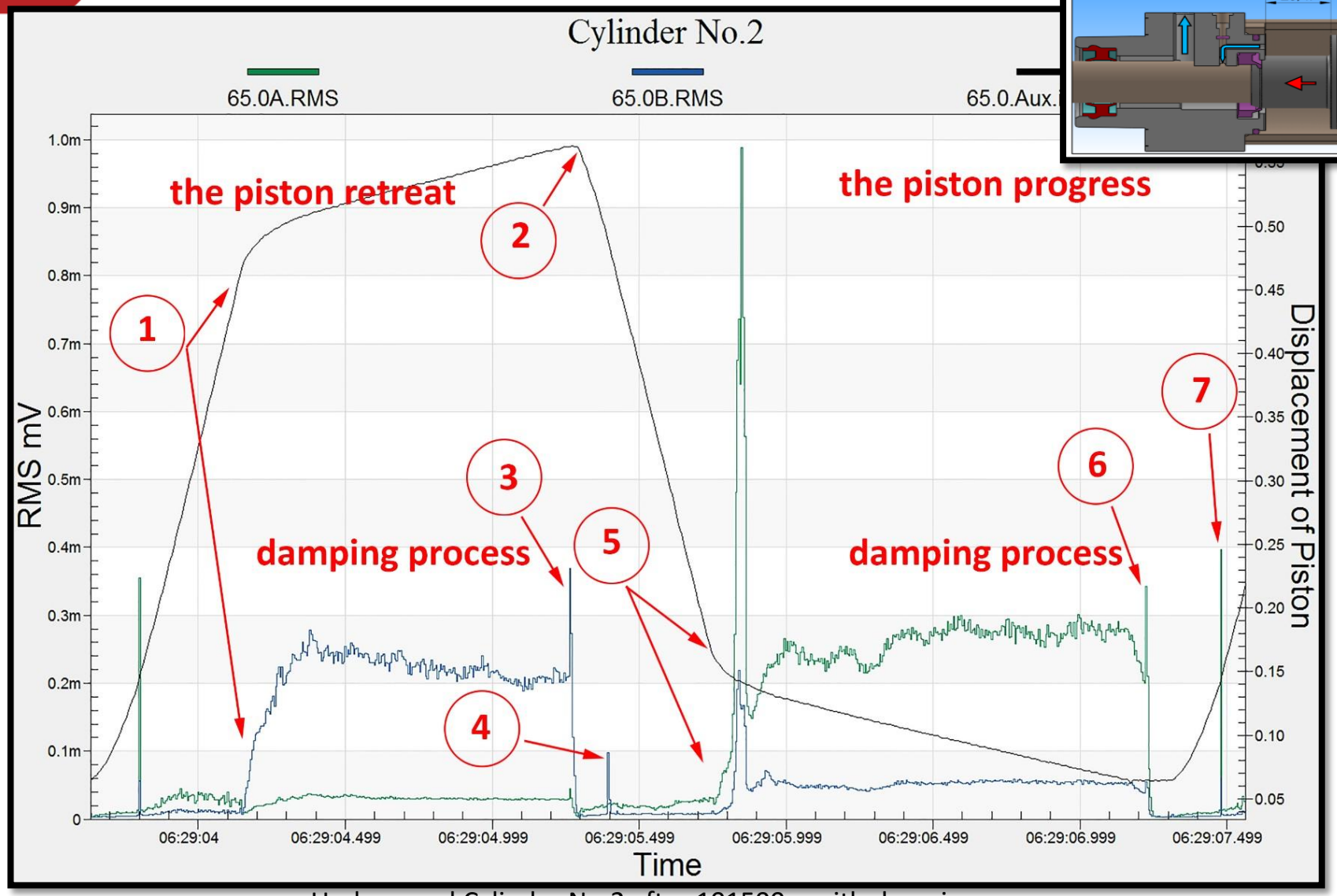
Signal spectrum of cylinder No. 4

Amplitude

(a) Intact cylinder

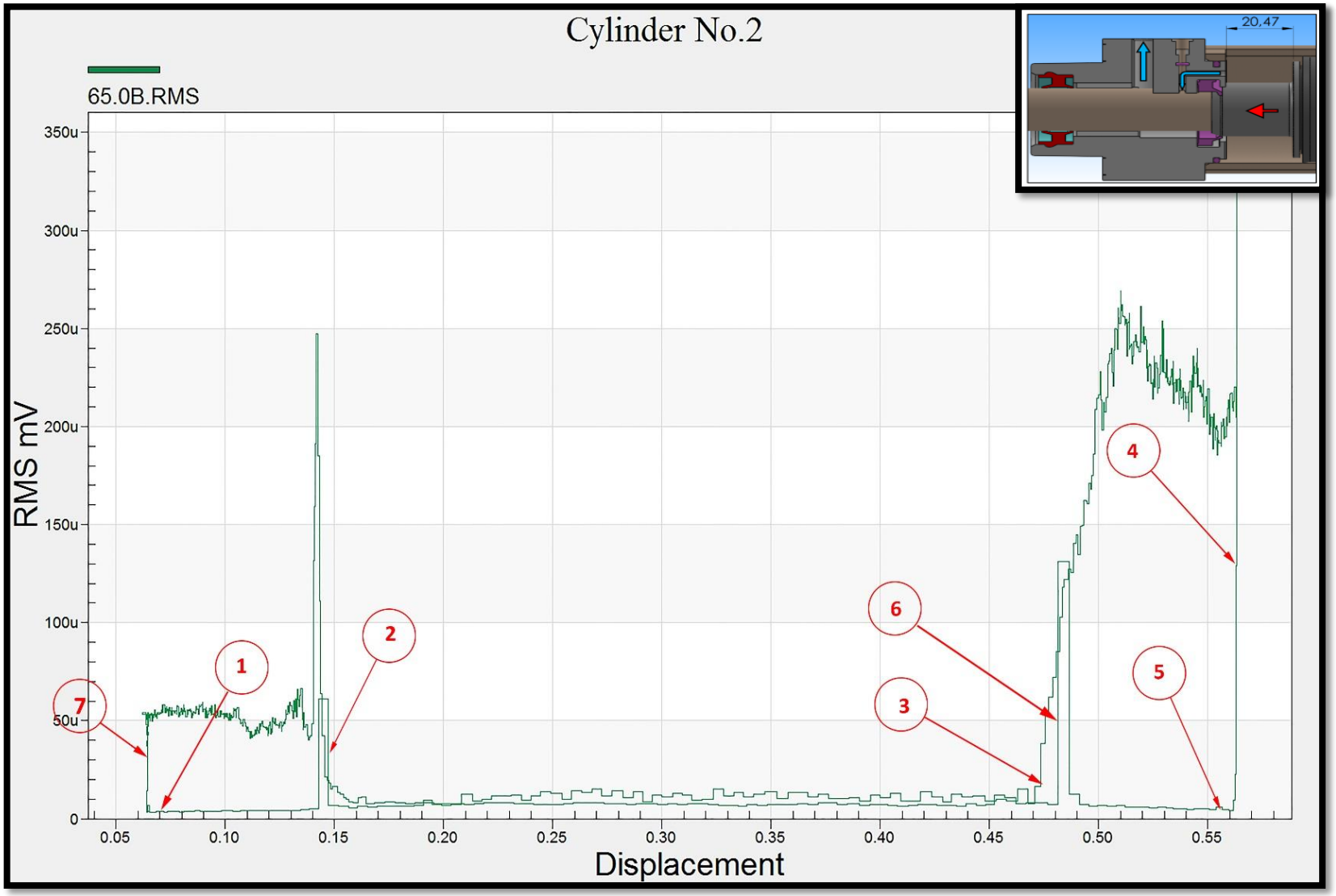
(b) Damaged cylinder

Current state solution of dissertation



Undamaged Cylinder No.2 after 101500c_with damping

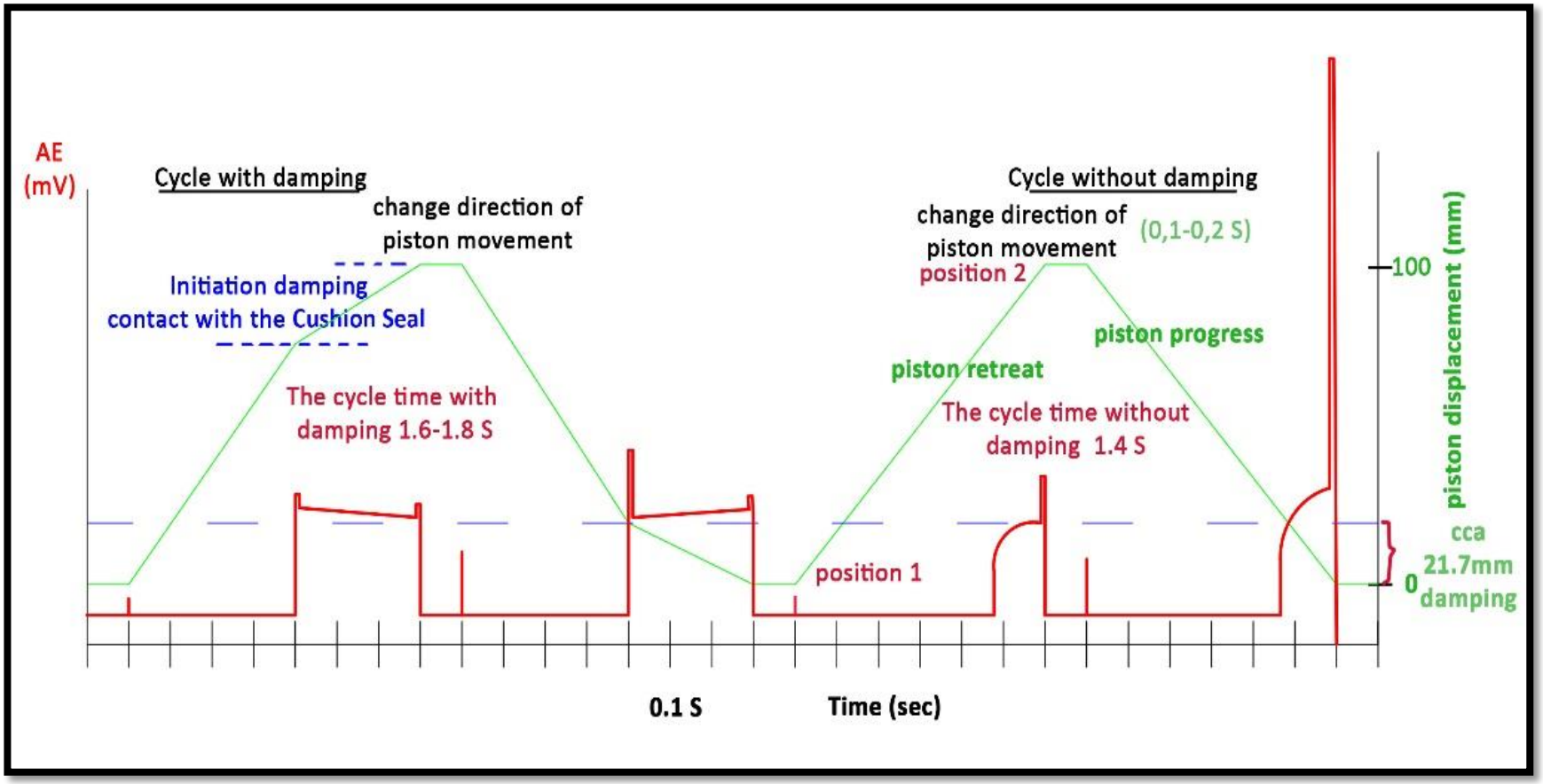
Current state solution of dissertation



Undamaged Cylinder No.2 after 101500c_with damping

Solution suggestion and future work

1. Loads on cylinder.
2. Cylinder Cycling .
3. Simulation of movement and treatment the signal



kinematic scheme of intact cylinder show us the progress and retreat stroke and response of AErms to this movement.

Conclusion

Current results show good reliability, repeatability and conformity of AE.

Coefficient detection DAE is lower than D.

The most serious defects of cylinders are those that have a large degree of severity S2.

The average energy of acoustic emission signal RMS is one of the most important parameters.

Frequency spectrum analysis is inappropriate parameter which used in pneumatic cylinder.

Author or co-author of publications from the area of Ph.D

1. Pavel MAZAL, Houssam MAHMOUD, Miroslav JÁNA, Vladimír BUKÁČEK, František VLAŠIC: Use of Acoustic Emission Method to Identify Damage of Pneumatic Cylinders, In NDE for Safety / Defektoskopie 2015, Brno 2015, p 81 - 90, ISBN978-80-214-5280-0.
2. Pavel MAZAL, Frantisek VLASIC, Houssam MAHMOUD, Miroslav JANA: The Use of Acoustic Emission Method for Diagnosis of Damage of Pneumatic Valves, In XIXth World Conference on NDT, Munchen, Germany 2016, ISBN 978-3-940283-78-8, USB edition, 10 pages.
3. Houssam MAHMOUD, Frantisek VLASIC, Pavel MAZAL: Simulation of Operational Loading of Pressure Equipment by Means of Non-Destructive Testing. In Metal 2015, Brno 2015.
4. Houssam MAHMOUD, Pavel MAZAL, Miroslav JANA, Frantisek VLASIC: Damage Identification Of Pneumatic Components By Acoustic Emission. In European Conference on AE Testing (EWGAE 2016), Prague, Sept. 2016, will be published.
5. Pavel MAZAL, Houssam MAHMOUD, Petr DOSTAL, Michal CERNÝ, Michal SUSTR, Jaroslav ZACAL: Cooperation Of Mendel University And Brno University Of Technology In The Field Of Biological Applications Of Ae Method. . In European Conference on AE Testing (EWGAE 2016), Prague, Sept. 2016, will be published.

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http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.561.8728&rep=rep1&type=pdf

[10]YAN, Jin, Yang HENG-HU, Yang HONG, Zhang FENG, Liu ZHEN, Wang PING a Yang YAN. Nondestructive Detection of Valves Using Acoustic Emission Technique. DOI:10.1155/2015/749371. ISBN 10.1155/2015/749371. :
http://www.hindawi.com/journals/amse/2015/749371/

Thank you for attention

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