AMERAPEX NDT LLC

APPLICATION REPORT

ON

ACOUSTIC EMISSION TESTING

OF

PAPER MACHINE DRYING CANS

INTRODUCTION:

The use of Acoustic Emission Testing (AET) methods to inspect pressure components in the petrochemical and pulp and paper industry has proved to be both economically and reliable NDE method for several years. TAPPI funded a study on the use of AET in the inspection of Yankee Dryers.(Assignment No 4939/880420.04 1992).

A drying can is similar to the Yankee dryer in construction and type of material. There is however one draw back, in the recommended procedure calls for a increase in steam pressure to minimum 5% above the maximum pressure that the structure has seen in the last six months. This is not always possible as most mills are running their boilers at maximum pressure.

Recent research and studies have revealed that most of the failure mechanisms that take place in a drying can are thermally driven. High stresses are generated during the start up and cooling down process, these stresses are a result of the differential expansion due to the varying thickness' and different cooling and heat related thermal expansion. When a structures is subjected to this type of stress any discontinuities present will emit stress waves detectable by AET instrumentation.

BASIC PRINCIPALS:

The basic principle of AET is very similar to that utilized by the seismic industry. Just as the movement of the earth's crust in the form of an earth quake releases energy as a shock wave detectable by sensors. So structures themselves in the pulp and paper industry release energy detectable by sensors placed at strategic locations. The main difference between seismic and AET are the frequency spectrums used. The seismic industry uses low frequencies of 0 to 10 Hz that would create problems if used in noisy environments, another difference is the distance used between sensors. In the seismic industry, the sensors are placed many miles away from the source. AET uses frequencies of between 20 and 400 kHz, which allows the monitoring of equipment subject to high noise from pumps and liquids flowing in piping etc. Typical AET sensor spacing is in the order of 10 to 15 feet apart.

How this method is able to detect the presence of structurally significant defects is based on principle of fracture mechanics. If there are crack-like defects or deep corrosion pitting present and the structure is subjected to a stimulus (pressure, load or temperature changes) higher than the working stimulus, a localized stress concentration at the tip of the crack occurs. If this satisfies a stress as low as 60% of ultimate tensile (UT) of the material, energy is released in the form of a shock wave, detectable by the sensors located on the equipment and processed by signal conditioning instrumentation. AET only requires a stimulus of 10% above (this is the equivalent of 5% of UT) the highest that the structure has undergone in the last six months.

METHOD STATEMENT:

High cost of inspection and the limitations of the classic NDE methods have in the past created concerns in the Pulp and Paper Industry. Our company was approached recently to examine the possibility of using AET as a global test method to determine if any of the drying cans needed detail NDE. At the same time could the drying cans be up graded to operate at a higher pressure.

It is possible to inspect as much as 50 drying cans in one test but the economics and mobilization of technicians and equipment plus the time slot available made it better to inspect 12 cans in one test.

Four AET sensors with wave guides where mounted on each drying can, this enables good coverage as well as location of the area of concern for follow up inspection. The drying cans are at this stage stationary and the steam pressure turned off , wave guides and sensors can be mounted with the temperature as high as 400 ˚ F. After the system is calibrated and the system checked, a background baseline recording is taken, the steam pressure is then raised to the 50% (of operating pressure), at the same time the temperature is being raised, this forms the first or the thermal phase to the test. A separate data file is opened and the test is done with monitoring during the pressure increases and hold periods typically 65%, 85%, 100% and if possible 105%.

The recorded data is then analyzed for each drying can. Special filters are used to remove all extraneous data.

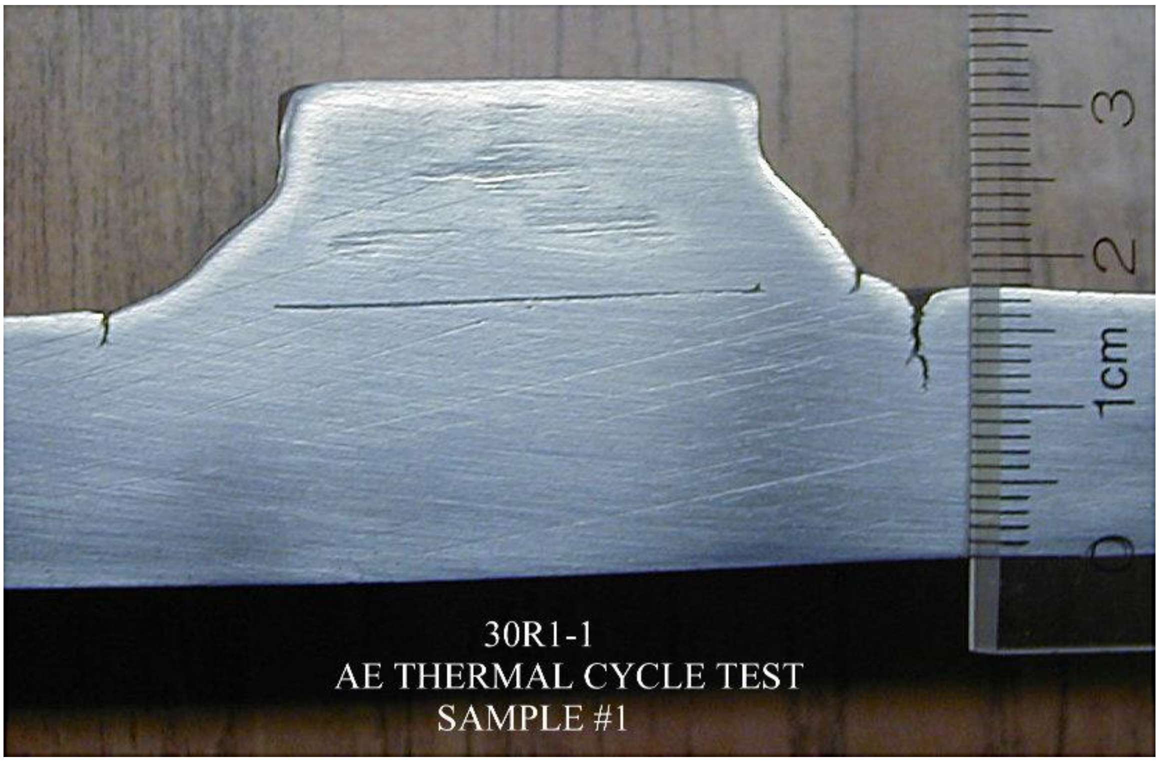
The following set of graphs is typical of the type of AET data display for a drying can test.

THERMAL TESTING:

Extensive research has been conducted on the AET detection of discontinuities during thermal stresses.

The most recent study was the use of material that had cracks each specimen with a different depth of crack, wave guides where mounted as per a normal field test and thermocouples attached on each side of the plate to record the temperature on each side.

The AET data was then recorded for the full period of the test.



Sample #1 had cracks that where 0.39 Inches deep

The AE data was tabulated for each sample and from this a crack criteria or CR value was established. The following is the table referred to in this discussion.

TABULAR DATA:

SAMPLE 1	Heat up	Hold	Cool down	Totals Hits	Energy/ Hit	Remarks
Macro Activity	2	5	87	94	689	Correction = 64,766 (CR)
Micro Activity	0	0	14	14	36	Total crack depth 0.39 inch
SAMPLE 2	Heat up	Hold	Cool down	Totals Hits	Energy/ Hit	Remarks
Macro Activity	9	3	3	12	1280	Correction = 15360 (CR)
Micro Activity	1	0	0	1	50	Total crack depth 0.275 inch
SAMPLE 3	Heat up	Hold	Cool down	Totals Hits	Energy/ Hit	Remarks
Macro Activity	12	1	0	13	456	Correction = 5928 (CR)
Micro Activity	2	0	0	2	34	Total crack depth 0.07
SAMPLE 4	Heat up	Hold	Cool down	Totals Hits	Energy/ Hit	Remarks
Macro Activity	20	0	15	35	457	Correction = 6,855 (CR)
Micro Activity	2	0	1	3	40	Total crack depth 0.2

The CR or correction ratio is derived by multiplying the number of macro matches by the energy per hit ratio.

If the above information is plotted on a graph (Figure 2) showing the CR value and the total depth of crack the correlation is good.

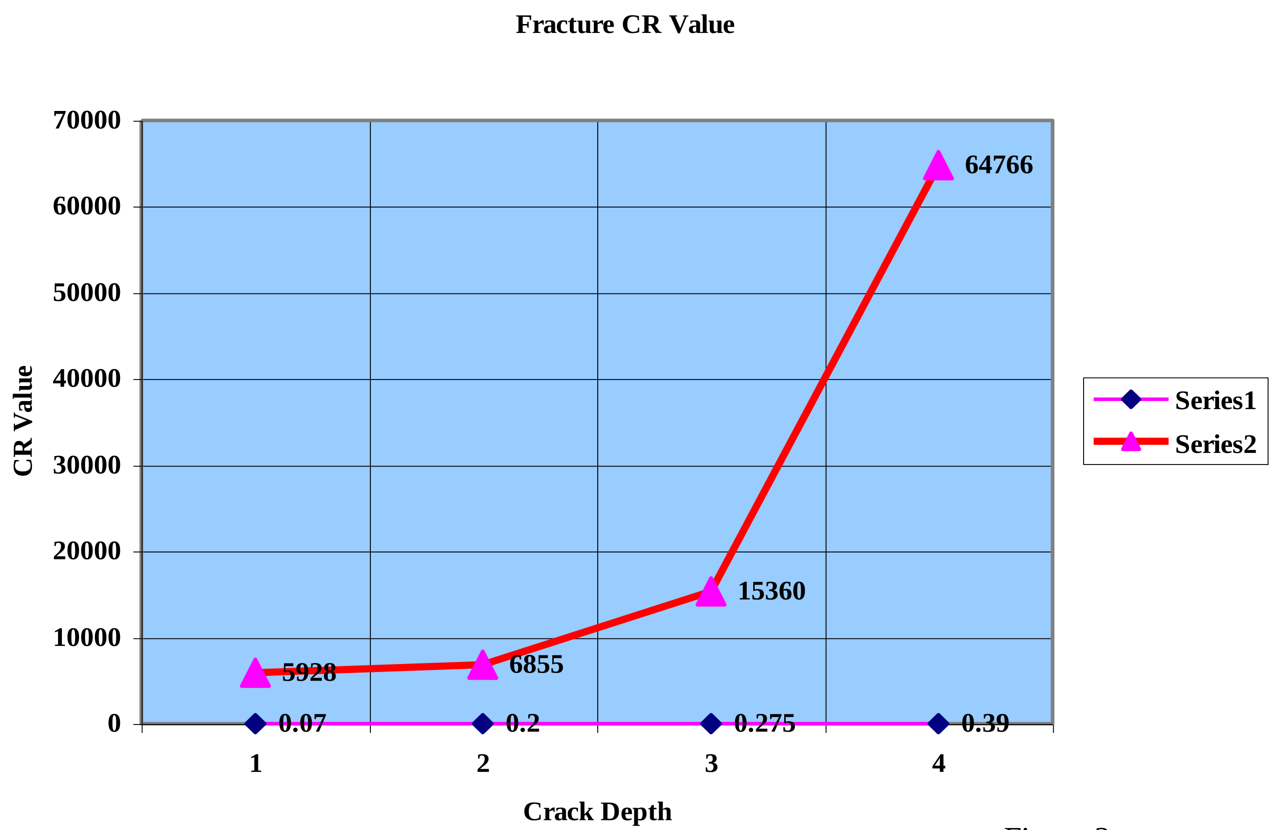


Figure 2

Figure 2 it the plot of the CR value in relation to the Crack depth for the different samples used in the study.

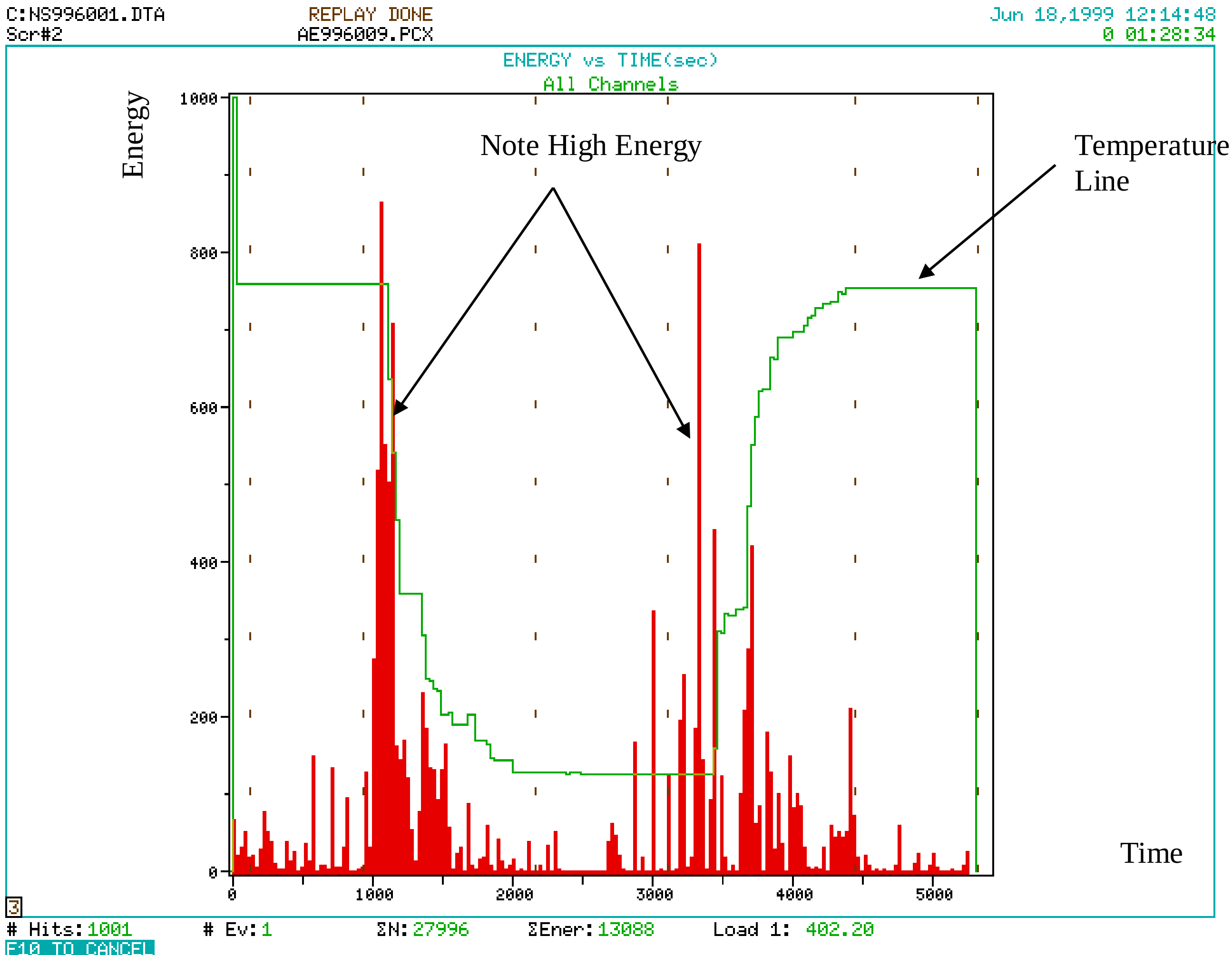


Figure 3

Figure 3. This graph is the recorded data during a in field thermal AET test. The green line is the temperature recorded during the test , the X axis is the time of test and the Y axis is the acoustic emission energy recorded. From the data recorded it can be concluded that the AE Energy increased during the temperature change. The AET results showed location of the activity and this was confirmed by removing the insulation in the area in question (a 9 inch crack)

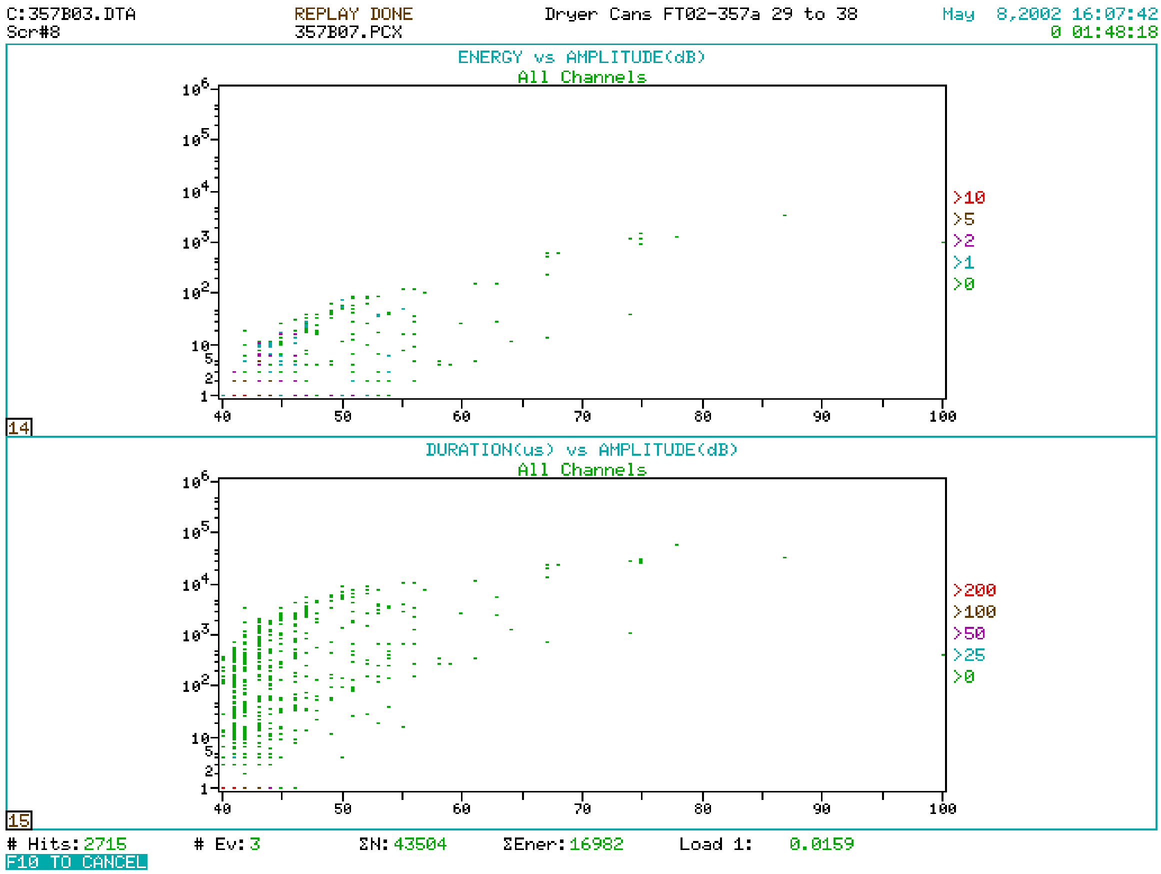


Figure 4

Figure 4. This is a set of two graphs identified as correlation graphs showing the relationship between amplitude X axis and the Energy or Duration of the AET hits recorded, used for data quality and the interpretation for the presence of possible cracks in the cans being tested. In this case it is noted that the amplitude / energy/ duration values are not high, indicating that the cans in this test have no detectable defects.

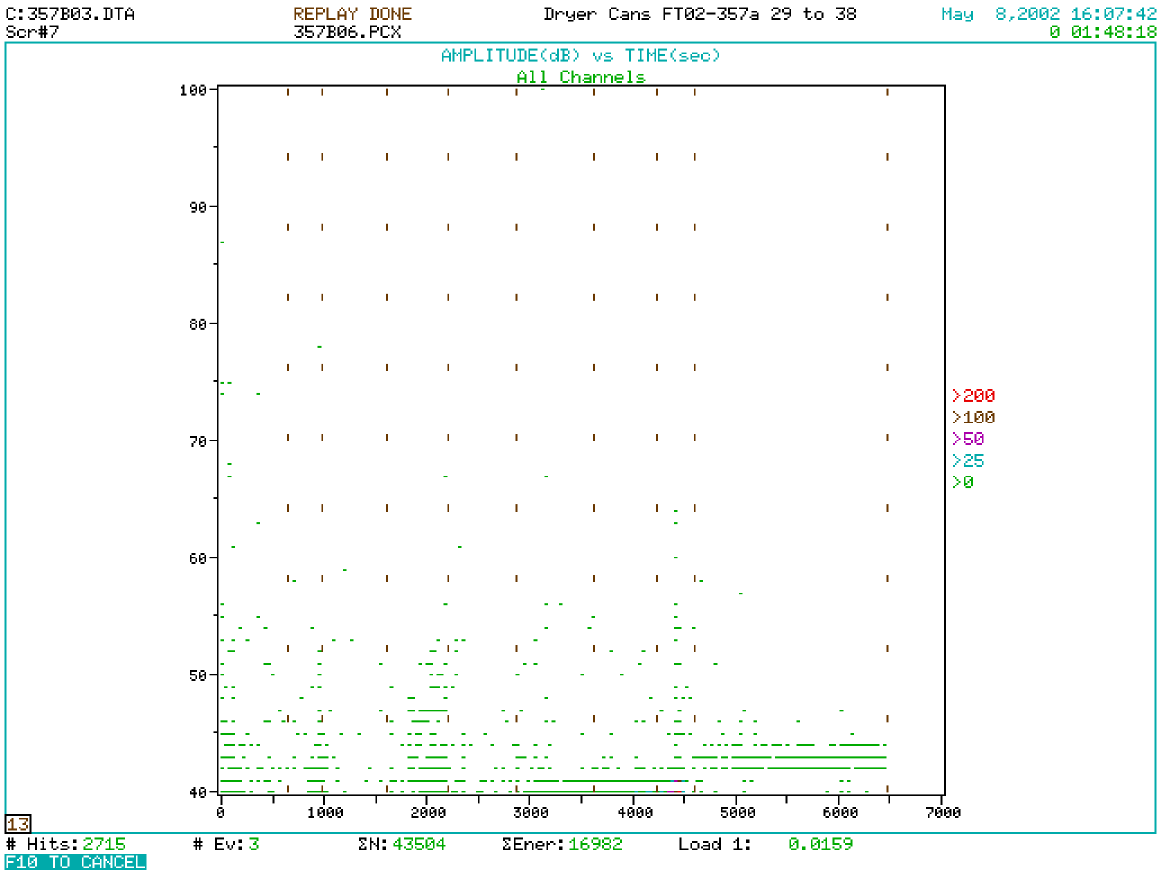


Figure 5.

This graph is the recording of the AE amplitude during the pressurization of the drying cans and from this graph it can be noted that there are no extra ordinary high hits detectable during this phase of the test. Leading to the interpretation that there are no significant defects present at this time.

COMPARISON OF THE DIFFERENT NDE METHODS:

The following classic NDE methods have been used in the past for inspection of drying cans but have serious limitations in both inspection time and detectability of significant defects.

1.0 **MAGNETIC PARTICLE INSPECTION:** This method is limited to the detection of surface breaking defects only and require the following conditions before a meaningful inspection can be done.

- 1.1 Surface preparation. The surfaces that are to be inspected must be clean and free of paint, grease or rust.
- 1.2 Surface temperature. The surface temperature must not be higher than 50 ˚ F specially if Kerosene is used as a medium.
- 1.3 Particle size of the powder is important as course dry powder will not detect fine hairline cracks.
- 1.4 Access full access to all surfaces to be inspected is a requirement.
- 1.5 Sizing. This method will only allow the measurement of the surface breaking length depth of crack cannot be measured using this method.

2.0 **LIQUID PENETRANT:** This method is limited to the detection of surface breaking defects only and require the following conditions before a meaningful inspection can be done.

- 2.1 Surface preparation. The surfaces that are to be inspected must be clean and free of paint, grease or rust. This is more critical in the case of this method.
- 2.2 Surface temperature. The surface temperature must not be higher than 40 ˚ F . Confined spaces have to be ventilated
- 2.3 Access full access to all surfaces to be inspected is a requirement.
- 2.4 It is important to realize that in order to detect a crack by this method the crack must have a surface opening of at least 1.9 micrometers, cracks smaller than this will not be detected.
- 2.5 Sizing. Linear length only can be measured.

3.0 **ULTRASONIC FLAW DETECTION:** This method has gained a lot of acceptance in recent years and with improvement of instrumentation and training of operators, is by far the best method to measure changes in wall thickness (corrosion) however it still has a lot of limitations in respect to the geometry of the equipment to be inspected. The following are some of the limiting factors.

- 3.1 Surface preparation. The surfaces that are to be inspected must be clean and free of paint, grease or rust. Surface roughness can be a limiting factor specially on rough castings such as those found on the heads of the drying can.

3.2 Access full access to one side of the surfaces to be inspected is a requirement.

3.3 Calibration. The sensitivity and gain settings must be done using similar materials to than being inspected, with known reflectors and geometry.

3.4 Surface temperature. The surface temperature must not be higher than 40 ˚ F .

4.0 **ACOUSTIC EMISSION TESTING:** The economic inspection and determination of fitness for service evaluation is becoming a very important factor in today's environment. AET is one of the few NDE methods that is not constrained by either temperature and geometry of the part being inspected. This method does however require the use of a stimulus such as pressure (steam is preferred as it is readily available) and change in operating temperature for the thermal test.

4.1 Surface preparation. Very little surface prep is needed as only four small locations on each side of the drying can is needed.

4.2 Access to the outside of the drying can is all that is necessary.

4.3 Surface temperature is not a limiting factor, it is suggested that the thermal test start with the temperature between 100 and 200 ˚ F.

COST SAVINGS:

When considering a NDE method it is important to take the cost of inspection into account .

1.0 Time to conduct the inspection. For this we must consider the inspection of at least 12 drying cans. Mobilization costs are not taken into account.

	MT	PT	UT	AET
Surface prep.	12 hrs	13 hrs	10 hrs	1 hr
Inspection full	48 hrs	48 hrs	24 hrs	2 hrs
Calibration	0	0	1 hr	6 hrs
Total Time	60 hrs	61 hrs	35 hrs	9 Hrs
Relative cost	$3,000	$3,000	$2,200	$4,200
Paper Machine down time	70 hrs	70 hrs	55 hrs	9 hrs

CONCLUSIONS:

From the past experience and analysis it can be noted that the use of AET is very favorable and should be seriously considered as the NDE method of the future.

For further information about the applications described in this document, or any other application you may require, contact. AMERAPEX NDT LLC.
by telephone at 713-263-0900 or Fax 713-263-0922 or by e-mail to info@amerapex.com