D2SERVICE

Design of 2 Technologies & Applications to Service

Work package.	**WP2:** Analysis of servicing costs and lessons learned from field test from major markets
Deliverable.	**D2.1:** Interim report with preliminary results
Period covered:	01.09.2015 – 01.01.2016
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1 Summary

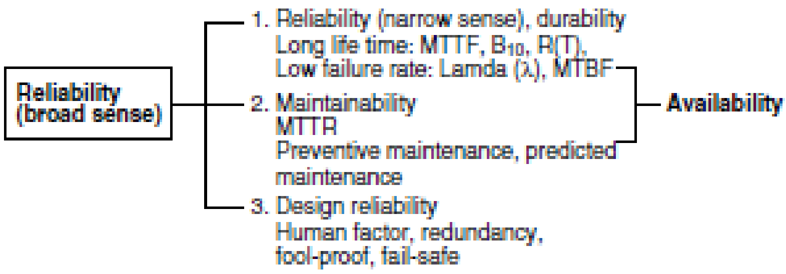
During this first phase of the program, DTP has been generated a survey questionnaire to identify service needs based on the partners experience from former and ongoing demonstration projects. The partners have experience form national projects in Germany, Italy and Denmark. Also experience from the European project ene.field will be included in the survey. The survey will focus on characterizing and quantify the failures observed that have required service. The failures will be grouped in external and internal failures according to what caused the failure. It is expected that the failure analyses will be the bases for prioritizing the design for service activities. As the most common service needs will have initial focus. For this work package partners' willingness to share information is critical.

2 Interim report with preliminary results

The survey questionnaire will be followed up by interviews with relevant person at the partners and will focus on more detailed information including:

- Definitions of reliability,
- service cost,
- service time,
- spare part cost, etc.

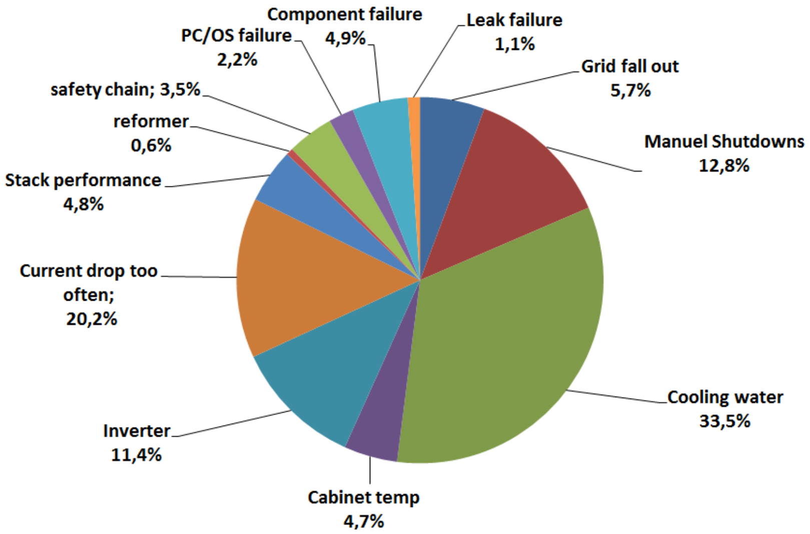
We have investigated the different method to define reliability using a Panasonic publication “Reliability ASCTB47E 201402-T” attached. The article present 5 different measures to assess reliability: Degree of reliability, MTBF, MTTF, Failure rate and Safe life. The failure rate seems to most accessible method to described failure rate and is defined as the ratio between the total failure count and the operating hours. An agreement with the consortium is needed to agree on common definition and need to define what reliability level is needed to reach the micro CHP and supplemental power market.



Regarding service cost, service time and spare part cost, a common denominator unit could be to use a unit based €cent/kW of net exported to the grid/end user which can directly be translated into the OPEX of the machine.

- Trigger for service intervention, logistics, handling and disposal/refurbishing
- Listing of typical failure modes
- Preventive maintenance schemes used
- Service input proposals from installers and early end-users
- National standards related to service operation

Based on the work in WP2 we look forward to be able to present circle diagrams similar to the one shown here for each of the programs.



In order to be able to realize this we need a very open communication around failures experienced. However all will benefit from being open in this project. We urge all the partners to supply the information in an open spirit.

3 Conclusion

The activities have started but for now no conclusion can be made!

4 Example of first Questionnaire

1. What is your role in the funded project listed above?

    a. OEM

    b. Service provider

    c. Hardware supplier

    d. Others_______________ (Please specify)

2. How many system have you deployed in the fields for each project listed below?

D- Callux	
IT Chrisalide	
Danish Micro CHP	
Enefield	
Others	

3. Can you describe the region? If several, please group deployed system by region. Info needed to establish correlation between failure and air quality, gas quality, water quality, rural area, coastal area, density of population, latitude, altitude.

4. In what kind of environment are the system installed? (please specify ratio %)

    a. Building basement

    b. Ground floor indoor

    c. Ground floor outdoor cabinet

5. What is the operating mode? (If deferent from system to system, precise amount of system per operating mode)

    a. Constant Current

    b. Constant Power

    c. Electrical load following

    d. Thermal load following

6. How many shutdown have your systems experienced on average? (all shut down included)

7. How many hours have the systems be operated on average?

8. Per average system, what kind of shut down have you experience?

    a. _% Emergency (trigger by safety chain)
    b. _% Fault
    c. _% Normal ie. daily shut down
    d. _% Service
    e. _% Summer shut down

9. The aim of the question is to clearly distinguish shut down related to system failure to shut down caused by external factors. Among the shut-down listed under Q 5, what percentage of the shut-down is related to external factors ie, like lightning, failure because of grid instability or lack of heating demand etc..? _%

10. System internal failure: Per average system and related to question 9, how many failures (in %) are related to:

    a. Air supply?
    b. Cooling circuit?
    c. Process water?
    d. Fuel quality?
    e. Control?
    f. Power electronics?
    g. Stack?
    h. Reformer?

11. System external failure: Per average system and related to question 9, how many failures (in %) are related to:
    a. Grid instability (lightning, grid parameters outside inverter requirements, RCD – residual current device)
    b. Gas supply interruption
    c. Heat demand household installation failure

12. How much shutdowns are related to leakage?

13. How many service visits have you performed per sites - operating hours?
    a. Plan _ (replacement or serviceable items – preventive maintenance)
    b. Unplanned_ (site troubleshooting, repairs etc..)

14. How many service tasks have been performed remotely per sites - operating hours?

15. What is the cost of planned service intervals ie DI replacement, air filter replacement, desulphuriser, others?
    a. Labor (please specify intervention time)
    b. Parts

16. Who has performed the service?
    a. Plumber
    b. Electrician
    c. OEM service department
    d. Utility service department
    e. Mixed_______________ (Please specify)
    f. Others_______________ (Please specify)

17. What is the average Installation and commissioning time in FTE hours?

18. With which profession have you observed the most challenges?

    a. Plumber
    b. Electrician
    c. OEM service department
    d. Utility service department
    e. Mixed________________ (Please specify)
    f. Others________________ (Please specify)

19. Does the service task comply with any National standards? If yes please specify which one.

5 Attachment

RELIABILITY

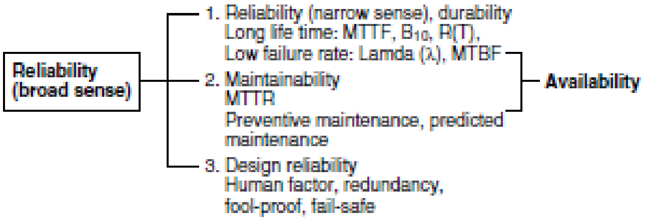
WHAT IS RELIABILITY?

1. Reliability in a Narrow Sense of the Term

In the industrial space, reliability is a measure of how long a particular product operates without failure.

2. Reliability in a Broad Sense of the Term

Every product has a finite service lifetime. This means that no product can continue normal service infinitely. When a product has broken down, the user may throw it away or repair it. The reliability of repairable products is recognized as "reliability in a broad sense of the term". For repairable products, their serviceability or maintainability is another problem. In addition, reliability of product design is becoming a serious concern for the manufacturing industry. In short, reliability has three senses: i.e. reliability of the product itself, serviceability of the product, and reliability of product design.



3. Intrinsic Reliability and Reliability of Use

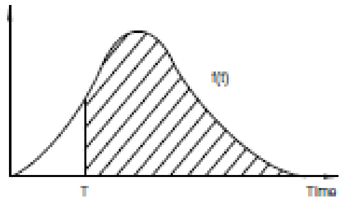
Reliability is "built" into products. This is referred to as intrinsic reliability which consists mainly of reliability in the narrow sense.

Product reliability at the user's site is called "reliability of use", which consists mainly of reliability in the broad sense. In the relay industry, reliability of use has a significance in aspects of servicing.

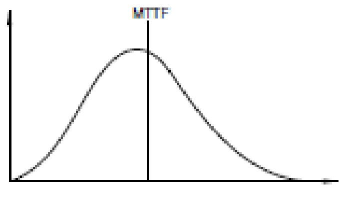
RELIABILITY MEASURES

The following list contains some of the most popular reliability measures:

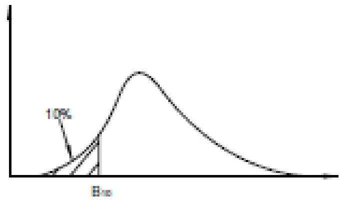
Reliability measure	Sample representation
Degree of reliability R(T)	99.9%
MTBF	100 hours
MTTF	100 hours
Failure rate λ	20 fit, 1%/hour
Safe life B_{10}	50 hours



(a) R(T)



(b) MTTF



(c) Safe life

1. Degree of Reliability

Degree of reliability represents percentage ratio of reliability. For example, if none of 10 light bulbs has failed for 100 hours, the degree of reliability defined in, 100 hours of time is 10/10 = 100%. If only three bulbs remained alive, the degree of reliability is 3/10 = 30%.
The JIS Z8115 standard defines the degree of reliability as follows:
The probability at which a system, equipment, or part provides the specified functions over the intended duration under the specified conditions.

2. MTBF

MTBF is an acronym of mean time between failures. It indicates the mean time period in which a system, equipment, or part operates normally between two incidences of repair. MTBF only applies to repairable products. MTBF tells how long a product can be used without the need for repair.
Sometimes MTBF is used to represent the service lifetime before failure.

3. MTTF

MTTF is an acronym of mean time to failure. It indicates the mean time period until a product becomes faulty MTTF normally applies to unrepairable products such as parts and materials.
The relay is one of such objective of MTTF.

4. Failure Rate

Failure rate includes mean failure rate and momentary failure rate.
Mean failure rate is defined as follows:

Mean failure rate = Total failure count/ total operating hours

In general, failure rate refers to momentary failure rate. This represents the probability at which a system, equipment, or part, which has continued normal operation to a certain point of time, becomes faulty in the subsequent specified time period.
Failure rate is often represented in the unit of percent/hours.
For parts with low failure rates,

"failure unit (Fit) = 10^{-9} /hour"

is often used instead of failure rate.
Percent/count is normally used for relays.

5. Safe Life

Safe life is an inverse of degree of reliability. It is given as value B which makes the following equation true:

$1 - R(B) = t\%$

In general, "B[1 – R(B)] = 10%" is more often used. In some cases this represents a more practical value of reliability than MTTF.

Reliability

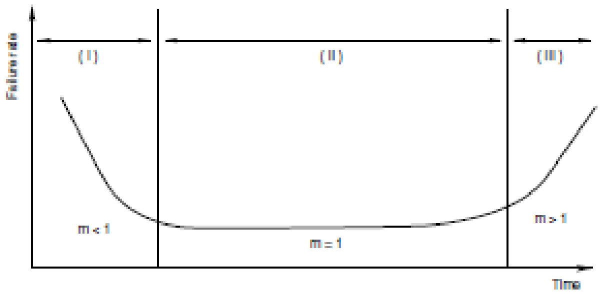
FAILURE

1. What Is Failure?
Failure is defined as a state of system, equipment, or component in which part of all of its functions are impaired or lost.

2. Bathtub Curve
Product's failure rate throughout its lifetime is depicted as a bathtub curve, as shown below. Failure rate is high at the beginning and end of its service lifetime.

(I) Initial failure period
The high failure rate in the initial failure period is derived from latent design errors, process errors, and many other causes. Initial failures are screened at manufacturer's site through burn-in process. This process is called debugging, performing aging or screening.

(II) Accidental failure period
The initial failure period is followed by a long period with low, stable failure rate. In this period, called accidental failure period, failures occurs at random along the time axis. While zero accidental failure rate is desirable, this is actually not practical in the real world.



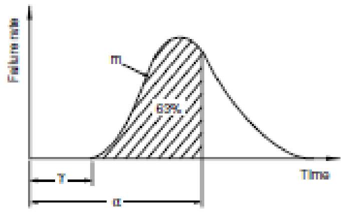
(III) Wear-out failure period
In the final stage of the product's service lifetime comes the wear-out failure period, in which the life of the product expires due to wear of fatigue. Preventive maintenance is effective for this type of failure. The timing of a relay's wear-out failure can be predicted with a certain accuracy from the past record of uses. The use of a relay is intended only in the accidental failure period, and this period virtually represents the service lifetime of the relay.

3. Weibull Analysis
Weibull analysis is often used for classifying a product's failure patterns and to determine its lifetime. Weibull distribution is expressed by the following equation:

$$f(x) = \frac{m}{\alpha}(\chi-\gamma)^{m-1} e^{-\frac{(\chi-\gamma)^m}{\alpha}}$$

where
m : Figure parameter
α : Measurement parameter
γ : Position parameter

Weibull distribution can be adopted to the actual failure rate distribution if the three variables above are estimated.



The Weibull probability chart is a simpler alternative of complex calculation formulas. The chart provides the following advantages:
(1) The Weibull distribution has the closest proximity to the actual lifetime distribution.
(2) The Weibull probability chart is easy to use.
(3) Different types of failures can be identified on the chart.

The following describes the correlation with the bathtub curve. The value of the figure parameter "m" represents the type of the failure.
(1) When $m < 1$: Initial failures
(2) When $m = 1$: Accidental failures
(3) When $m > 1$: Wear-out failures

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