DAMAGE BOUNDARY METHOD

1. DAMAGE BOUNDARY METHOD

With the Damage Boundary (shortened D-Bound) test method:

- The quality, operational, and functional reliability of a product is secured at a constant level.
- In practice, modifications on existing products or on new products being placed on the market will not present any problems when the ‘old’ and new products have identical D-Bound curves.
- No damage occurs during a drop or impact as long as the critical velocity change or the critical acceleration is not exceeded during testing. This also applies for any specific shock or drop test requirement.
- A product with a critical acceleration level of say 300 m/s² will meet any type of shock requirement with an acceleration level below the critical one, regardless of the shock pulse (½ sine, sawtooth, square wave) and duration.
- Cushioning material is not required (saves on costs) when the critical velocity change is above the velocity change due to the required drop height for the packaging and/or product. The velocity change is a measure for the drop height.
- The reliability factor of translating test results into practical situations is high.

2. APPLICATIONS

Some of the applications are:

- Reducing or determining the minimum required amount of cushioning material in packaging.
- Verifying shock resistance of equipment and products for the defence and civil industries (transport, earthquake, reliability).
- Optimising products or component joints, e.g. (adhesives, bolts, pop rivets).
- Comparing similar products or verifying product modifications.
- Guarding against excessive safety measures implemented in the design (overkill)..
- Reduction of the number of tests, e.g. skip long duration bump testing (unless intended for low-cycle fatigue).

3. EXECUTION DAMAGE BOUNDARY TEST

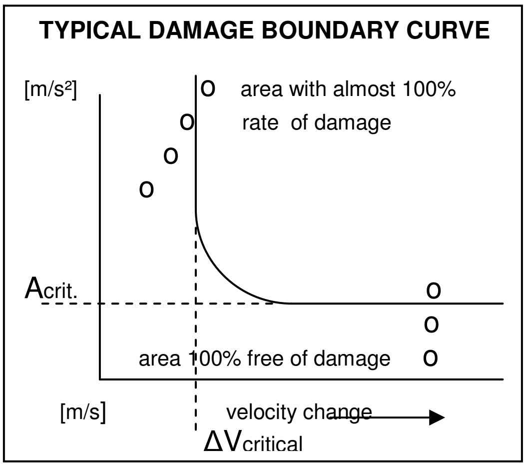
The D-Bound-curve measures the fragility level of a product. A programmable shock-testing machine is used to determine the D-Bound-curve. Two types of shock pulses are used for this determination: a half sine and a square wave shock pulse. The duration and acceleration of the square wave is adjustable.
The measured critical acceleration (Ac) and critical velocity change (ΔVc) determine the D-Bound curve. The product is tested per axis (+/-). Depending on the planes of symmetry, a 2x3 test series is required to determine the critical velocity change, and 2x3 test series is required for the critical acceleration. The maximum number of test series is 12, requiring 4-5 shocks per direction to determine the first point of damage. Above the critical velocity change and acceleration levels, the possibility of damaging a product is almost 100%.
Based on our knowledge and experience, only one prototype product is needed to carry out a full D-Bound test. However, the test must be stopped just before the anticipated damage occurs, and in doing so, the results of the D-Bound curve might be slightly conservative. Nevertheless, the number of prototype products (most of the time expensive) is kept to a minimum this way. The margin between actual testing and the D-Bound-curve outcome can become significant when the single product method is applied on products or components that are brittle.

3.1 Determination critical velocity change:

The critical velocity change is determined with a half sine shock pulse. This shock pulse has a fixed duration (1-1.5 ms) and a wide range of acceleration levels (1000-6000m/s²). The drop height of the shock table is increased gradually until the first point of (unacceptable) damage to the product is attained.

3.2 Determination critical acceleration level:

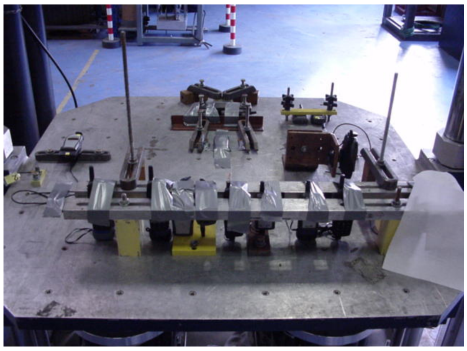
The critical acceleration is determined by means of a square wave shock pulse (20-1000m/s² - 5-60ms). A square wave is defined by 19 frequencies that excite all frequencies present in a product. A half sine shock pulse will usually excite only one frequency. At a constant drop height, the acceleration level increases gradually as duration decreases. The decreasing duration ensures that every possible frequency of the product will be excited eventually.



EVALUATION TESTRESULTS

Damage mostly concerns joints, incorrect loading of (brittle) materials and stress concentrations, whether or not combined with bending moments. Most damage is unnecessary and simply avoidable, without complex analyses.
Some attention paid in the design and engineeringphase to these aspects prevents 80-90% of this type of damage. Full integration of transport or shock requirements in the design gives almost 100% reliability to prevent this damage.

For S2T, a shock test is a **non-destructive test.** It means, a test proving that a product meets the shock requirements **without damage**.



Arrangement Sony Ericsson mobiles on shocktable. (S2T thanks Sony Ericsson for her co-operation concerning the picture and her working procedure).

Case:
S2T performs many D-Bound tests for Sony Ericsson. Sony Ericsson carries out these tests on their mobile phones and accessories:

- To ensure that their products meet the TŰV shock and bump tests (for the automotive industry) without sustaining damage.
- To quantify levels of quality and ruggedness.
- For comparison purposes between products and accessories.
- To simulate user environments.
- To reduce the number of tests.

The mobile phones are mounted in various directions on the shock table. The cost of mobile phones is lower when compared to the cost of the shock test, and this makes it cost-effective to test three prototypes in three axes simultaneously. Mounting the mobiles on the shock table and verification are the most time consuming tasks. It is possible to determine both by utilising a 2x2 test series: the critical velocity change and critical acceleration.
Decisions for improvement can be taken based on the test results. For instance, it is possible to determine the brittle or ductile behaviour of glue and the weakness or strength of glued joints; this being extremely valuable for the design of the phone and any subsequent modifications. Another reason for using the D-Bound method for Sony Ericsson is to realise cost reductions by optimising material type and thickness, dimensions, glued joints, etc. Mobiles requiring less material are lighter and can therefore be designed more compactly. This does not affect the quality of the mobile and the shock resistance does not change; it actually improves most of the time.
The optimisation procedure for Sony Ericsson fits in nicely with the S2T philosophy. The S2T philosophy is that given identical product costs, a higher shock resistance will result in less weight, better quality, and lower production and service costs.
A good shock design is realised when material properties concerning strength and stiffness are optimised and superfluous material is kept to a minimum. Superfluous material causes higher loads on joints because each kilo/gram of mass has to be multiplied by 50 - 500 m/s², or more.
Higher loads require stronger, and/or more bolts and glue; bending moments increase and create the stresses on the same material thickness or dimensions.
The damage usually affects the joints; the incorrect loading of (brittle) materials, stress concentrations, possibly in combination with bending moments. Yet, most damage is unnecessary and can be easily avoided, even without complex analyses.
Dedicating more time and effort into the design and engineering phase will prevent 80 to 90% of this type of damage from occurring. Full integration of transport or shock requirements in the design phase gives a near 100% reliability factor towards damage prevention.
Do we have your attention? S2T would be pleased to send you information about the possibilities we have to offer. You are also welcome to visit us for a demonstration or support.

S2T: YOUR DYNAMIC TEST CENTER FOR ALL YOUR TESTS

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