What is the drop-weight tear test?

Steel pipelines are widely used to transport energy in the form of liquid petroleum and natural gas. The steel used in the manufacture of these pipelines must have high strength and toughness, and high resistance to fracture. Over the last few decades, it has become recognized that the drop-weight tear test (DWTT) better represents the ductile fracture resistance than the Charpy test since it utilizes a specimen that has the full thickness of the pipe and has a fracture path long enough to reach steady-state fracture resistance. The zones of ductile and brittle fracture during DWTT characterize the quality of pipeline steels.

The drop weight tear test (DWTT), specified in API RP 5LR or ASTM E436, was developed in the early 1960s at the Battelle Memorial Institute, USA, to overcome some limitations of the 'Pellini' Drop-weight test. Drop weight tear testing is a material characterization test aimed at avoiding brittle fracture and ensuring crack arrest in pipelines (seamless or welded).

Overview

HUALONG WCJ Series is mainly used for drop weight tear test (DWTT) of Ferritic Steels, to observe specimen fracture surface after impact within the temperature that fracture type is converted from non-ductility to ductility. This test method is that hammer striker with some weights is raised to some height then released. Free drop hammer impacts and tears the specimen. After impact, proportions of ductile fracture (shear) and cleavage on the fracture surfaces are measured.

Impactek data acquisition system is available to be introduced into DWTT tester, through which can upgrade simple uninstrumented DWTT tester to an instrumented DWTT tester who is able to measure the amount of force required to break a specimen, and this enables calculation of separate values for initiation energy and propagation energy, those impact resistance information gathered by doing instrumented testing can be used by Research and Development to evaluate the effects of metallurgical variables such as composition, processing, heat treatment can have on the fracture resistance of new or existing materials. Test results may also be used to indicate particular steel’s suitability for use in a specific application.

Application range

This testing machine accords with the relevant requirements of Standards for DWTT such as: metallic materials—Drop-weight tear tests of ferritic steels.

1. API RP 5L3
2. ASTM E 436
3. EN 10274
4. GB 8363

The recommended practice API RP 5L3 issued by the American Petroleum Institute (API) describes the testing procedure to be used on large-drop impact testers. A specimen supported at both ends is impacted with a cold-press-fitted notch, with the point of impact opposite the notch. Since the specimen thicknesses are very large sections of actual pipeline tubes, high impact energies of up to 100,000 Joule are necessary to break the specimen.

Main features

1. Regulating impact energy by adjusting the lifting height and mass of the weights.
2. Very robust construction stands up to the rigours of high energy testing to provide high reliability with a minimum of downtime.
3. The shock absorbers are equipped to absorb the residual energy after breaking the specimen to protect the weight and anvil from destroying.

4. Easily interchangeable contact parts simplify maintenance and reduce cost of ownership.

5. State-of-the-art testing accommodates impact energies up to 100,000J and specimens up to 50mm thick.

6. Automated specimen loading provides compliance with cycle times required by test methods, while maintaining operator safety.

7. Very rigid base and anvils ensure very low flexure under high test loads.

8. Guided mass system to ensure that the impact geometry is correct throughout the entire test.

9. High quality, easy to use control software ensures consistency and enhances throughput. It displays height, energy, drop weight and velocity at predetermined parameters.

10. Optional temperature soak bath

11. Optional automatic specimen feeding system.

12. Optional Impact data acquisition system.

13. Responsive life-time technical support.

**Safety:**

Safety is compliant with the European CE machinery safety directive (89/392/EEC & 91/368/EEC – machinery safety).

Electrical and mechanical safety interlocking. Testing is possible only after checking of all safety parameters, to comply with OSHA requirements (USA).

Access to specimen area protected by interlocked doors when the machine is running.

Emergency stop function electrically isolates winch drive and release.

All safety systems dual circuit and fail-safe.

No unsafe release of the drop weight possible under any of the following conditions:

(a) Failure of mains power supply

(b) Failure of compressed air supply

(c) Failure of control software
Touch-screen Panel is for manual operation, commissioning as well as status observation
## Drop Weight Tear Tester (DWTT)

<table>
<thead>
<tr>
<th>Maximum energy (J)</th>
<th>30kJ</th>
<th>40kJ</th>
<th>50kJ</th>
<th>60kJ</th>
<th>80kJ</th>
<th>100kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drop height (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Or upon request)</td>
<td>2</td>
<td>2.6</td>
<td>2.6</td>
<td>3.1</td>
<td>3.2</td>
<td>4.1</td>
</tr>
<tr>
<td>Resolution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact velocity (m/s)</td>
<td>5.4&lt;v&lt;7</td>
<td>5.4&lt;v&lt;7</td>
<td>5.4&lt;v&lt;7.9</td>
<td>5.4&lt;v&lt;7.9</td>
<td>5.4&lt;v&lt;8.96</td>
<td></td>
</tr>
</tbody>
</table>

### Drop weight (kg)

| Mass of drop weight frame (kg) | 800 | 800 | 1000 | 1300 | 1300 | 1300 |
| Mass of weight increments (kg) | 30  | 30  | 50   | 50   | 50   | 50   |
| Quantity of weight increments | 27  | 27  | 20   | 24   | 24   | 24   |
| Total mass of drop weight (kg) | 800+ (27*30) | 800+ (27*30) | 1000+ (50*24) | 1300+ (50*24) | 1300+ (50*24) | 1300+ (50*24) |
| Mass deflection | ±0.5% |
| Max. Raising speed (m/min) | 4 |

### Dimensions & Weight

| Dia. of guide column (mm) | Ø110 | Ø110 | Ø110 | Ø110 | Ø200 | Ø200 |
| Dia. of post (mm)         | Ø155 | Ø155 | Ø155 | Ø155 | Ø200 | Ø200 |
| Overall height of tower(m) | 6.2  | 6.2  | 6.2  | 7    | 7    | 7.4  |
| Gross weight of tower(kg) | 12000 | 14000 | 14000 | 15000 | 18000 | 20000 |

### Striker

- Radius of curvature 25.4mm ±0.1mm
- Centerline with respect to center of anvil supports: 0mm ±1.0mm
- Complies with API 5L3, ASTM E436, EN 10274

### Anvil

- Radius of curvature 15.0mm ±0.1mm
- Span 254.0mm ±1.0mm
- Complies with API 5L3, ASTM 436, EN 10274

### Specimens

- Width 76.0mm ± 3.0mm
- Length 305mm ± 50.0mm
- Thickness 6mm to 50mm
- Notch depth 5.1mm ± 0.51mm, Notch angle 45° ± 2°
- Notch radius 0mm to 0.05mm
- Planarity ±5mm
- Can accommodate specimens prepared according to standards API 5L3, ASTM 436, EN 10274

### Notch type of specimen

- Pressed or Chevron
**Drop Tower**

Four solid post ensure the high stiffness
Two guide columns to ensure that the drop weight hit right in the center of specimen, chrome plated surface ensure the longest life as well as lowest friction
Ladder to access top to facilitate installation and maintenance
Enclosed by squared mesh panels secure the whole drop tower from top to bottom.

Release of mass by rotation of hook on bottom of hoist mechanism, activation of both release cylinder and interlock cylinder required for release.

Self-lubricating bearing for the hoist mechanism and drop weight to ensure the lowest friction and maintenance

Weight increments flexibly to adjust the total mass of drop weight for different impact energy
Drop Weight Tear Tester

Shock absorbers, Anvil and Tup

Note: Tup with load cell inside is for data acquisition option (instrumented DWTT)

Winch
Easy to access for periodic inspection and maintenance

AC brushless servo motor fitted with brake, driving sling via precision gearbox
Protective Cage
Protective case secure the whole operation area

Interlock on the door
## Temperature soak bath (option)

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal construction</td>
<td>Bath and guides from 304 grade stainless steel.</td>
</tr>
<tr>
<td>Capacity</td>
<td>Sufficient to accommodate up to 10 (optional 12 pieces) specimens of thickness up to 50mm with minimum 26mm gap between each specimen.</td>
</tr>
<tr>
<td>Chamber access</td>
<td>Top loading, via pneumatically operated access door.</td>
</tr>
<tr>
<td>Temperature range</td>
<td>-80°C to +20°C.</td>
</tr>
<tr>
<td>Temperature accuracy (displayed versus actual)</td>
<td>± 1°C</td>
</tr>
<tr>
<td>Temperature stability (at set-point)</td>
<td>± 1°C</td>
</tr>
<tr>
<td>Cooling method</td>
<td>Compressors (liquid Nitrogen-aided refrigeration option)</td>
</tr>
<tr>
<td>Cooling medium</td>
<td>Ethanol 99.7-100% (absolute) AnalaR Galden ZT130 manufactured by Solvay (Alternative)</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Mineral insulated metal-sheathed type K thermocouples.</td>
</tr>
<tr>
<td>System control</td>
<td>Via control software; input of set point; soak time, ramp rate. Sounds alarm when complete</td>
</tr>
<tr>
<td>Temperature indication</td>
<td>By touch screen on cage and PC monitor.</td>
</tr>
<tr>
<td>Protection</td>
<td>Isolation of cooling via safety contactor triggered by industry standard temperature monitor. Requires manual re-set when tripped.</td>
</tr>
<tr>
<td>Cooling medium consumption (estimated)</td>
<td>90 litres of Ethanol or Galden, based on reducing full load of specimens to –80°C and holding for 2 hours</td>
</tr>
</tbody>
</table>

Sufficient to accommodate up to 10 (optional 12 pieces or more) specimens of thickness up to 50mm with minimum 26mm gap between each specimen.

More specimens accommodation for semi-auto machine is available upon request.
liquid Nitrogen-aided refrigeration option

Liquid Nitrogen can significantly speed up the refrigeration. We are using the Liquid Nitrogen to cool down the cooling medium to certain temperature, then compressors continue cooling the cooling medium to the pre-set temperature, liquid Nitrogen-aided refrigeration can significantly reduce the refrigeration time up to one hour.
Automatic Specimen Feeding System (option)

It is pneumatically operated pick and place system
Load cycle time < 9s
Placement of specimen within ± 0.5mm (X & Y axes)
Instrumentation (option)

Impactek data acquisition system is available to be introduced into DWTT tester, through which can upgrade simple uninstrumented DWTT tester to an instrumented DWTT tester who is able to measure the amount of force required to break a specimen, and this enables calculation of separate values for initiation energy and propagation energy, those impact resistance information gathered by doing instrumented testing can be used by Research and Development to evaluate the effects of metallurgical variables such as composition, processing, heat treatment can have on the fracture resistance of new or existing materials. Test results may also be used to indicate particular steel’s suitability for use in a specific application.

Specifications

Impact force measured by force load cell, mounted immediately behind hammer.  
Non-Linearity: <0.05% of rated output.  
Repeatability: <0.05% of rated output.  
Hysteresis: <0.05% of rated output.  
Zero balance: <1.0% of rated output (zero offset compensation by amplifier)  
Operating temperature range: -20°C to +80°C.  
Safe overload: ±125%.

Data acquisition option (National instruments (USA))

Sample rate: 1,000,000 samples per second.  
Resolution: 16 bits  
Data points captured per impact: 3,000  
Calibrated accuracy: ±0.1%  
Timebase accuracy: ±0.01%  
Triggering: from force signal, laser/photodiode detector or external trigger

Signal conditioning

By strain-gauge amplifier  
Bandwidth: DC - 50KHz, –3dB.
**Software**

**Platform**
PC running Microsoft Windows XP / 7.
Supplied system minimum specification of 4GB RAM, 120GB hard drive, CD-RW, 21" display.

**Environment**
Compatible with MS Office 2003/XP and above

**Purpose**
Control of impact testing sequence and analysis of impact data.

**Access control**
Two, password protected levels:
1. Operator access, to perform pre-defined DWTT tests.
2. Administrator access, to control the type of test performed and the required documentation information etc. also for sensitive configuration and calibration functions.

**Language**
The DWTT system has a Human Machine Interface that is easy to use and works in English only, other languages upon request

**Data Analysis**

- **System configuration**

- **Percent shear calculation**
**Functional Specification**

**Semi-Auto (Without Automatic Specimen Feeding System)**

- The operator opens the specimen door on bath.
- The operator takes a specimen from the cooling bath and places it on the alignment table.
- The operator closes the specimen door.
- The rest of the sequence is automatic: the autoloader picks the specimen up, places it on the anvil, the clamp is applied and the autoloader returns to the home position. The drop weight is then released and the broken pieces of the specimen conveyed to the right side of drop tower.

**Shortages:**

1. the cycle time might exceed 10 seconds (See note)
2. Low temperature hazard
3. Cooling medium hazard to health (Ethanol)
4. Cooling medium flammable (Ethanol)
5. Safety hazard-Operator has to stand close to the machine

**Note:** Remove the specimens from the bath and break as described herein within a time period of 10-s. If the specimens are held out of the bath longer than 10 s return them unbroken to the bath for a minimum of 10 min. (API 5L3, ASTM E436, EN 10274)

**Automatic (With Automatic Specimen Feeding System)**

- The operator configure the drop height, cooling temperature and soak time on software.
- The rest of the sequence is automatic: the specimen feeding system takes a specimen from the cooling bath, places it on the anvil, then returns to the home position. The drop weight is then released and the broken pieces of the specimen conveyed to the right side of drop tower.

**Advantages:**

1. Cycle time completely within 10 seconds (See note)
2. Safe to operators

*The system is designed for a minimum cycle time of 3 minutes. Cycle times under 3 minutes with very low energy absorption might result in over heating of the shock absorbers, and consequently to damage.*
### Notch Pressing Machine (Option)

<table>
<thead>
<tr>
<th>Function</th>
<th>For pressed notching of DWTT specimens. Complies with the requirements of standards EN10274, API 5L3 and AST E436.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>Hydraulically operated, consisting of a rigid H-frame with a T-slotted bed on which the specimen is supported and clamped while the notch is pressed into it.</td>
</tr>
<tr>
<td>Safety</td>
<td>Front and rear guarding with safety interlocks prevents unconditional access to moving parts.</td>
</tr>
<tr>
<td>Maximum notching force</td>
<td>1000kN</td>
</tr>
<tr>
<td>Features</td>
<td>Easy to replace chisel</td>
</tr>
</tbody>
</table>
## Installation

**Foundation**

Piling as required by underlying soil to suit maximum impact energy  
Deep trench foundations filled with low-Q concrete  
Concrete topped by HUALONG-supplied interface plate, levelled to 0.5 over 1000mm

**Interface plate and foundation bolts**

![Interface plate and foundation bolts](image)

**Utilities**

**Compressed air**  
Compressed air is required at 90 psi at 10 cfm (620 kPa at 0.0047 cms) for the pneumatic systems in the latch and safety pin as well as automatic feeding system. A 1/4 inch (6.4 mm) pipe thread to connect a flexible hose is standard on the machine, but this may be modified per customer requirements.

**Hydraulic Oil (Notch Pressing Machine)**  
Mobil 46# or 68# Anti-wear hydraulic oil, 40liters

**Ethanol (Temperature soak bath)**  
Ethanol is required at 90 liters to be filled into the cooling chamber from the same door that used to install specimen.