FINAL REPORT
MAY 1995

REPORT NO. 93-22

STEEL STRAPPING
JOINT STRENGTH
EVALUATION

19960710 038

Prepared for:
U.S. Army Defense Ammunition
Center and School
ATTN: SMCAC-DET
Savanna, IL  61074-9639

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U.S. ARMY
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SAVANNA, ILLINOIS  61074-9639
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The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by USADACS, Transportation Engineering Division (SMCAC-DET), to conduct a study to assess the maximum strengths of 1-1/4- and 2-inch steel strapping sealed with crimping sealers and notching sealers. The configurations tested included the following for both sizes of strapping:

- a. One strapping seal per strap with one crimp per seal.
- b. One strapping seal per strap with two crimps per seal.
- c. Two strapping seals per strap with two crimps per seal.
- d. One strapping seal per strap with one notch per seal.

(Continued)
19. ABSTRACT (Continued)

e. One strapping seal per strap with two notches per seal.
f. Two strapping seals per strap with two notches per seal.

Results are as follows:

a. 1-1/4-inch strapping sealed with a crimping sealer is stronger than when sealed with a notching sealer.
b. 2-inch strapping sealed with a notching sealer is stronger than when sealed with a crimping sealer.
c. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a crimping sealer.
d. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a notching sealer.
e. The strength of 2-inch strapping is increased with the addition of a second seal when sealed by either the crimping or notching sealer.
f. Use of a seal other than what is specified by the manufacturer of the sealer can significantly reduce the breaking strength of the strapping.
TABLE OF CONTENTS

PART  |  PAGE NO.
---|---
1. INTRODUCTION | 1-1
   A. BACKGROUND | 1-1
   B. AUTHORITY | 1-1
   C. OBJECTIVE | 1-1
   D. CONCLUSIONS | 1-1
2. ATTENDEES | 2-1
3. TEST PROCEDURES | 3-1
4. TEST RESULTS | 4-1
5. PHOTOGRAPH | 5-1
6. GRAPHS | 6-1
7. TEST NOTES | 7-1
PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center and School (USADACS), Validation Engineering Division (SMCAC-DEV), was tasked by USADACS, Transportation Engineering Division (SMCAC-DET), to conduct a study to assess the maximum strengths of 1-1/4- and 2-inch steel strapping sealed with crimping sealers and notching sealers.

B. AUTHORITY. The test was accomplished IAW mission responsibilities delegated by U.S. Army Armament, Munitions and Chemical Command (AMCCOM). Reference is made to the following:


2. AMCCOM-R 10-17, Mission and Major Functions of USADACS, 13 January 1986.

C. OBJECTIVE. The purpose of these tests was to determine what difference, if any, existed between the breaking strengths of steel strapping sealed with a notching sealer versus steel strapping sealed with a crimping sealer.

D. CONCLUSIONS. Results are as follows:

a. 1-1/4-inch strapping sealed with a crimping sealer is stronger than when sealed with a notching sealer.

b. 2-inch strapping sealed with a notching sealer is stronger than when sealed with a crimping sealer.
c. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a crimping sealer.

d. The strength of 1-1/4-inch strapping is increased with the addition of a second seal when sealed with a notching sealer.

e. The strength of 2-inch strapping is increased with the addition of a second seal when sealed by either the crimping or notching sealer.

f. Use of a seal other than what is specified by the manufacturer of the sealer can significantly reduce the breaking strength of the strapping.
PART 2
AUGUST 1993 AND MAY 1995

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PART 3

TEST PROCEDURES

The breaking strength of the 1-1/4- and 2-inch strapping was determined by placing a loop of the steel strapping around four pins in a test fixture with the desired seal for the test conducted (see part 5). A load cell and displacement gauge were utilized to measure the breaking strength and strap elongation during each test. The six configurations tested for both the 1-1/4- and 2-inch steel strapping were as follows:

a. One strapping seal per strap with one crimp per seal.
b. One strapping seal per strap with two crimps per seal.
c. Two strapping seals per strap with two crimps per seal.
d. One strapping seal per strap with one notch per seal.
e. One strapping seal per strap with two notches per seal.
f. Two strapping seals per strap with two notches per seal.

The test fixtures pulled apart at an average rate of 1.17 inches per minute. The test was continued until a point at which the maximum strength of the strapping had been obtained. During testing, both load force and load displacement were recorded so that precise results could be obtained. Five straps were broken for each configuration to avoid the possibility of skewed results.
PART 4

TEST RESULTS

As described in part 3, steel strapping was tested in six different configurations for two different sizes of steel strapping with five straps being broken for each configuration. During each test, the mode of failure was observed for each strap and recorded in order to provide an accurate record for the test results (see part 7). Initially, six sets of straps were tested for the 1-1/4-inch strapping and six sets were tested for the 2-inch strapping. The 1-1/4-inch straps were tested with a Signode seal, part number 107DG, and the 2-inch straps were tested with a Signode seal, part number 207. While analyzing the test data, a discrepancy was noted for the breaking strengths of the 2-inch straps with crimped seals (see table 2). After further investigation, the seal that was used for the tests with the 2-inch strapping and crimping sealer was determined to be improper for the sealer that was used for these tests. After consultation with the manufacturer of the 2-inch crimping sealer, the tests with the 2-inch crimping sealer were conducted again utilizing Signode seal 208DG. The 208DG seal had a grit coating on the inner side of the seal. The results obtained from the second set of tests for the 2-inch steel strapping and crimping sealer indicated a more reasonable maximum breaking strength for the crimping sealer than had been obtained during the first series of tests. As can be seen in tables 1 and 2 and in the summary graph in part 6, the crimping sealer had a slightly higher average breaking strength than the notching sealer for the 1-1/4-inch strapping, while the notching sealer had a higher average breaking strength than the crimping sealer for the 2-inch strapping. The large difference in breaking strengths for the 2-inch strapping for the crimping sealer with the wrong seal and with the 208DG seal can also be seen in table 2 as well as the summary graph in part 6.
<table>
<thead>
<tr>
<th></th>
<th>Single Seal</th>
<th>Single Seal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Notch</td>
<td>Single Crimp</td>
</tr>
<tr>
<td></td>
<td>5,176</td>
<td>5,363</td>
</tr>
<tr>
<td></td>
<td>5,330</td>
<td>5,965</td>
</tr>
<tr>
<td></td>
<td>5,884</td>
<td>6,120</td>
</tr>
<tr>
<td></td>
<td>5,851</td>
<td>6,201</td>
</tr>
<tr>
<td></td>
<td>5,762</td>
<td>5,851</td>
</tr>
<tr>
<td>Average:</td>
<td>5,601</td>
<td>5,900</td>
</tr>
</tbody>
</table>

|                  | Single Seal | Single Seal |
|                  | Double Notch| Double Crimp|
|                  | 8,049       | 8,862       |
|                  | 7,935       | 8,927       |
|                  | 8,480       | 9,237       |
|                  | 8,341       | 8,927       |
|                  | 8,691       | 8,797       |
| Average:         | 8,299       | 8,950       |

|                  | Double Seals | Double Seals |
|                  | Double Notches| Double Crims |
|                  | 7,625        | 9,172        |
|                  | 7,585        | 9,106        |
|                  | 8,016        | 8,935        |
|                  | 8,268        | 9,391        |
|                  | 7,625        | 9,497        |
| Average:         | 7,824        | 9,220        |
Table 2

Breaking Strengths of 2-Inch Steel Strapping (all values in pounds)

<table>
<thead>
<tr>
<th>Single Seal Notch</th>
<th>Single Seal Crimp</th>
<th>Single Seal (208DG) Crimp</th>
</tr>
</thead>
<tbody>
<tr>
<td>6,160</td>
<td>2,490</td>
<td>6,396</td>
</tr>
<tr>
<td>5,737</td>
<td>3,507</td>
<td>6,877</td>
</tr>
<tr>
<td>5,493</td>
<td>2,343</td>
<td>6,877</td>
</tr>
<tr>
<td>5,672</td>
<td>2,433</td>
<td>7,031</td>
</tr>
<tr>
<td>6,437</td>
<td>2,710</td>
<td>6,641</td>
</tr>
<tr>
<td>Average:</td>
<td>5,900</td>
<td>6,764</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Single Seal Notch</th>
<th>Single Seal Crimp</th>
<th>Single Seal (208DG) Crimp</th>
</tr>
</thead>
<tbody>
<tr>
<td>12,988</td>
<td>5,583</td>
<td>10,522</td>
</tr>
<tr>
<td>12,638</td>
<td>5,151</td>
<td>10,067</td>
</tr>
<tr>
<td>13,395</td>
<td>5,306</td>
<td>10,026</td>
</tr>
<tr>
<td>13,118</td>
<td>5,070</td>
<td>10,498</td>
</tr>
<tr>
<td>12,614</td>
<td>5,241</td>
<td>11,003</td>
</tr>
<tr>
<td>Average:</td>
<td>12,951</td>
<td>10,423</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Double Seal Notches</th>
<th>Double Seal Crimps</th>
<th>Double Seal (208DG) Crimps</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,036</td>
<td>10,628</td>
<td>19,238</td>
</tr>
<tr>
<td>20,377</td>
<td>11,312</td>
<td>18,978</td>
</tr>
<tr>
<td>19,482</td>
<td>11,287</td>
<td>19,140</td>
</tr>
<tr>
<td>20,459</td>
<td>10,653</td>
<td>18,750</td>
</tr>
<tr>
<td>19,401</td>
<td>11,182</td>
<td>18,880</td>
</tr>
<tr>
<td>Average:</td>
<td>19,951</td>
<td>18,997</td>
</tr>
</tbody>
</table>
PART 5

PHOTOGRAPH
AO317-SCN93-243-4499. This photograph shows the test setup that was used to determine the breaking strength of both the 1-1/4- and 2-inch steel strapping.
PART 6

GRAPHS
Summary Results from the
Steel Strapping Joint Evaluation
Results from the 1-1/4 Inch and 2-inch Steel Strapping Joint Evaluation

Average Strap Breaking Strength (Pounds)
Test Data from
1-1/4-Inch Strapping: 1 Seal, 1 Crimp
Test 1: 1.25 Inch Banding, 1 Seal, 1 Crimp

Load Force in Pounds

Vertical Displacement in Inches
Test 2: 1.25 Inch Banding, 1 Seal, 1 Crimp
Test 3: 1.25 Inch Banding, 1 Seal, 1 Crimp

Load Force in Pounds

Vertical Displacement in Inches
Test 4: 1.25 Inch Banding, 1 Seal, 1 Crimp

Y: FAMOS/1d0007 X: FAMOS/1d0008
E-5

Load Force in Pounds

Vertical Displacement in Inches
Test 5: 1.25 Inch Banding, 1 Seal, 1 Crimp
Test Data from
1-1/4-Inch Strapping: 1 Seal, 2 Crimps
Test 1: 1.25 Inch Banding, 1 Seal, 2 Crimps

Vertical Displacement in Inches

Load Force in Pounds
Test 2: 1.25 Inch Banding, 1 Seal, 2 Crimps

Vertical Displacement in Inches

Load Force in Pounds
Test 3: 1.25 Inch Banding, 1 Seal, 2 Crimps

Vertical Displacement in Inches

Load Force in Pounds

Graph showing the relationship between load force in pounds and vertical displacement in inches for Test 3 with 1.25 Inch Banding, 1 Seal, and 2 Crimps.
Test Data from
1-1/4-Inch Strapping: 2 Seals, Double Crimps
Test 1: 1.25 Inch Banding, 2 Seals, 2 Crimps

Load Force in Pounds

Vertical Displacement in Inches
Test 2: 1.25 Inch Banding, 2 Seals, 2 Crimps

Load Force in Pounds

Vertical Displacement in Inches
Test 4: 1.25 Inch Banding, 2 Seals, 2 Crimps

Load Force in Pounds

Vertical Displacement in Inches
Test Data from
1-1/4-Inch Strapping: 1 Seal, 1 Notch
Test 1: 1.25 Inch Banding, 1 Seal, 1 Notch
Test 3: 1.25 Inch Banding, 1 Seal, 1 Notch
Test 4: 1.25 Inch Banding, 1 Seal, 1 Notch

Vertical Displacement in Inches
Test 5: 1.25 Inch Banding, 1 Seal, 1 Notch

Vertical Displacement in Inches

Load Force in Pounds
Test Data from
1-1/4-Inch Strapping: 1 Seal, 2 Notches
Test 2: 1.25 Inch Banding, 1 Seal, 2 Notches

Load Force in Pounds

Vertical Displacement in Inches
Test 4: 1.25 Inch Banding, 1 Seal, 2 Notches

Vertical Displacement in Inches

Load Force in Pounds
Test 5: 1.25 Inch Banding, 1 Seal, 2 Notches

Vertical Displacement in Inches

Load Force in Pounds
Test data from
1-1/4-inch Strapping: 2 Seals, Double Notches
Test 2: 1.25 Inch Banding, 2 Seals, 2 Notches

Vertical Displacement in Inches
Test 3: 1.25 Inch Banding, 2 Seals, 2 Notches

Load Force in Pounds

Vertical Displacement in Inches
Test 4: 1.25 Inch Banding, 2 Seals, 2 Notches

Load Force in Pounds

Vertical Displacement in Inches
Test Data from
2-Inch Strapping: 1 Seal, 1 Crimp
Test 1:  2 Inch Banding, 1 Seal, 1 Crimp

Vertical Displacement in Inches
Test 3: 2 Inch Banding, 1 Seal, 1 Crimp

Load Force in Pounds

Vertical Displacement in Inches
Test 5: 2 Inch Banding, 1 Seal, 1 Crimp

![Graph showing load force in pounds against vertical displacement in inches.]
Test Data from
2-Inch Strapping: 1 Seal, 2 Crimps
Test 1: 2 Inch Banding, 1 Seal, 2 Crimps

Vertical Displacement in Inches

Load Force in Pounds
Test 2: 2 Inch Banding, 1 Seal, 2 Crimps

Vertical Displacement in Inches

Load Force in Pounds
Test 3: 2 Inch Bonding, 1 Seal, 2 Crimps
Test 4: 2 Inch Banding, 1 Seal, 2 Crimps

Vertical Displacement in Inches
Test 2: 2 Inch Banding, 2 Seals, 2 Crimps

Y: FAMOS/ln0023 X: FAMOS/ln0024

Load Force in Pounds

Vertical Displacement in Inches
Test 5: 2 Inch Banding, 2 Seals, 2 Crimps

Vertical Displacement in Inches
Test Data from
2-Inch Strapping: 1 Seal, 1 Notch
Test 1: 2 Inch Banding, 1 Seal, 1 Notch
Test 2: 2 Inch Banding, 1 Seal, 1 Notch

Vertical Displacement in Inches

Load Force in Pounds
Test 4: 2 Inch Banding, 1 Seal, 1 Notch

Vertical Displacement in Inches

Load Force in Pounds
Test 5: 2 Inch Banding, 1 Seal, 1 Notch

Vertical Displacement in Inches
Test Data from

2-Inch Strapping: 1 Seal, 2 Notches
Test 1: 2 Inch Banding, 1 Seal, 2 Notches

Vertical Displacement in Inches

Load Force in Pounds
Test 3: 2 Inch Banding, 1 Seal, 2 Notches
Test 4: 2 Inch Banding, 1 Seal, 2 Notches

vertical displacement in inches

load force in pounds
Test Data from
2-Inch Strapping: 2 Seals, Double Notches
Test Data from
2-Inch Strapping: 1 Seal (208DG), 1 Crimp
Test 1: 2 Inch Banding, 1 Seal (208DG), 1 Crimp
Test 2: 2 Inch Banding, 1 Seal (208DG), 1 Crimp

Load Force in Pounds

Vertical Displacement in Inches
Test 3: 2 Inch Banding, 1 Seal (208DG), 1 Crimp

Vertical Displacement in Inches
Test 4: 2 Inch Banding, 1 Seal (208DG), 1 Crimp

Vertical Displacement in Inches
Test Data from
2-Inch Strapping: 1 Seal (208DG), 2 Crimps
Test 2: 2 Inch Banding, 1 Seal (208DG), 2 Crimps

Vertical Displacement in Inches
Test 3: 2 Inch Banding. 1 Seal (208DG). 2 Crimps

Vertical Displacement in Inches

Load Force in Pounds
Test 5: 2 Inch Banding, 1 Seal (208DG), 2 Crimps

Vertical Displacement in Inches
Test Data from
2-Inch Strapping: 2 Seals (208DG), Double Crimps
Test 4: 2 Inch Banding, 2 Seals (208DG), 2 Crimps

[Graph showing load force in pounds vs. vertical displacement in inches]
Test 5: 2 Inch Banding, 2 Seals (208DG), 2 Crimps

Load Force in Pounds

Vertical Displacement in Inches
PART 7

TEST NOTES

Following are test synopsis and results.

a. **1-1/4-Inch Strapping: 1 Seal, 1 Crimp**

   All straps pulled through the seal during the test.

b. **1-1/4-Inch Strapping: 1 Seal, 2 Crimps**

   (1) Test 1: Strap pulled the seal apart.
   (2) Test 2: Strap pulled the seal apart.
   (3) Test 3: Strap broke.
   (4) Test 4: Strap pulled the seal apart.
   (5) Test 5: Strap pulled through the seal.

c. **1-1/4-Inch Strapping: 2 Seals, Double Crimps**

   All straps broke at an outer crimp.

d. **1-1/4-Inch Strapping: 1 Seal, 1 Notch**

   All straps pulled through the seal.

e. **1-1/4-Inch Strapping: 1 Seal, 2 Notches**

   All straps broke at an outer notch.

f. **1-1/4-Inch Strapping: 2 Seals, Double Notches**

   All straps broke at an outer notch.
g. 2-Inch Strapping: 1 Seal, 1 Crimp

All seals were pulled apart.

h. 2-Inch Strapping: 1 Seal, 2 Crimps

All seals pulled apart.

i. 2-Inch Strapping: 1 Seal, 1 Notch

All straps pulled through the seals, tearing the seals at the notch points.

j. 2-Inch Strapping: 1 Seal, 2 Notches

All straps pulled through the seals, tearing the seals at the notch points.

k. 2-Inch Strapping: 2 Seals, Double Notches

All straps broke at an outer notch.

l. 2-Inch Strapping: 1 Seal (208DG), 1 Crimp

All straps pulled through the seal.

m. 2-Inch Strapping: 1 Seal (208DG), 2 Crimps

(1) Test 1: Strap pulled through the seal.
(2) Tests 2 - 5: Seal pulled apart.

n. 2-Inch Strapping: 2 Seals (208DG), Double Crimps

All seals pulled apart.