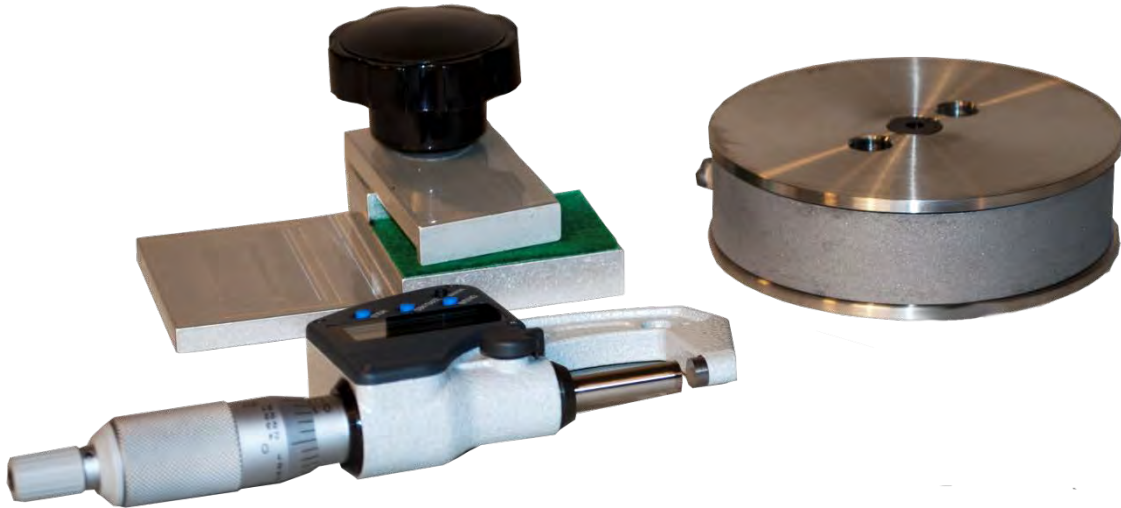


Circular Expansion Cement Curing Kit

Instruction Manual



Manual No. 101443617, Revision C

Instrument No. 205814

Expansion/Shrinkage Test Kit Instruction Manual

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Houston, Texas, USA

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1 Introduction

The ring expansion mold was developed to simulate the expansion properties of cement compositions placed into the annulus of a well. The same mold can be used for determining shrinkage by slightly modifying the test procedure.

The atmospheric testing procedure can be found in the "Annular Ring Test" section of the API Recommended Practice 10B-5, Recommended Practice on Determination of Shrinkage and Expansion of Well Cement Formulations at Atmospheric Pressure, as well as this document.

1.1 Document Conventions

The following icons are used as necessary in this instruction manual.



NOTE. Notes emphasize additional information that may be useful to the reader.



CAUTION. Describes a situation or practice that requires operator awareness or action in order to avoid undesirable consequences.



MANDATORY ACTION. Gives directions that, if not observed, could result in loss of data or in damage to equipment.



WARNING! Describes an unsafe condition or practice that if not corrected, could result in personal injury or threat to health.



ELECTRICITY WARNING! Alerts the operator that there is risk of electric shock.



HOT SURFACE! Alerts the operator that there is a hot surface and that there is risk of getting burned if the surface is touched.



EXPLOSION RISK! Alerts the operator that there is risk of explosion.

2 Safety

Safe laboratory practices and procedures should be observed while operating and maintaining this ring expansion mold.

3 Procedure

Follow the procedures in this section for preparing and filling the mold, curing the specimen, and measuring the specimen's expansion or shrinkage.

3.1 Preparing the Mold

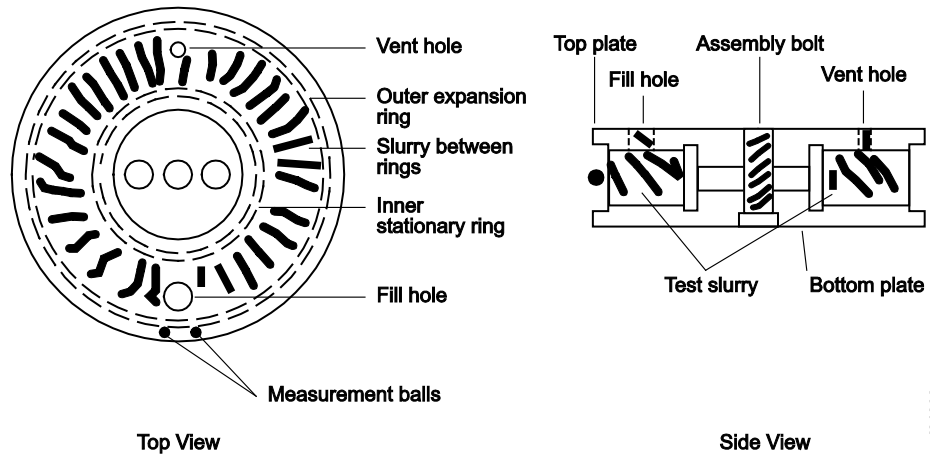
1. Clean the mold thoroughly.
2. Place a bead of high-temperature grease on the upper and lower plates where the inner stationary ring and the outer expansion ring touch.
3. Apply a very thin film of light oil to the inner and outer rings and to the top and bottom covers that will contact the cement. The thin film of light oil helps prevent the cement from bonding to the rings and allow the outer expansion ring to expand or contract without being restricted by cement bonded to it.
4. With the top cover inverted, place the inner and outer rings on the top cover.
5. Place the bottom cover over the inner and outer rings.
6. Insert the screw into the center hole from the bottom, and tighten the screw to hold the mold together.
7. Verify that the outer expansion ring rotates freely.
8. Place a small amount of high-temperature grease between the split in the outer ring. The grease will seal the split and prevent the slurry from leaking before it sets.
9. To test for shrinkage, coat the spacer block with grease, and place the block between the split in the outer expansion ring.

3.2 Filling the Mold and Taking Initial Measurements

1. Place the mold on a smooth flat surface so that the large and small holes are at the top of the mold.
2. Mix the slurry according to API procedures (or special mixing procedures, if required).
3. If high-temperature expansion testing is desired, the slurry may be preconditioned (especially if the expansion test is for the cement placed at the top of the column of cement) in an atmospheric or pressure consistometer. using the "Determination of cement compressive strength at the top of a long cement column" procedure in the "Well-simulation compressive strength tests"

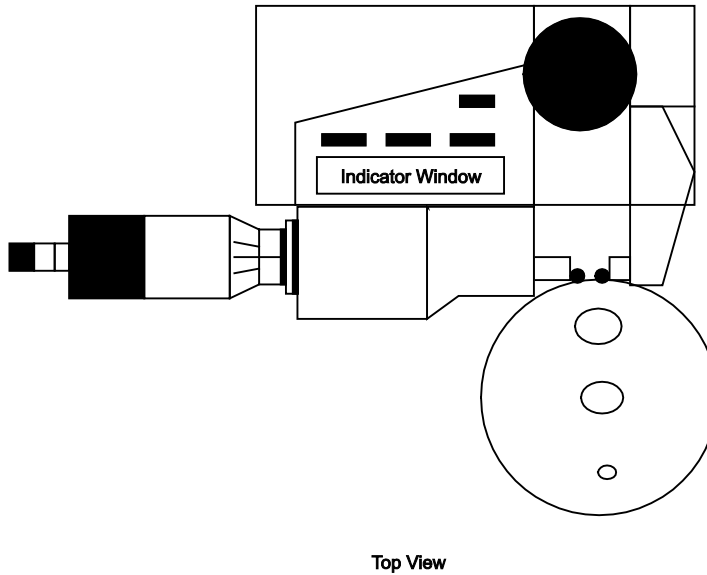
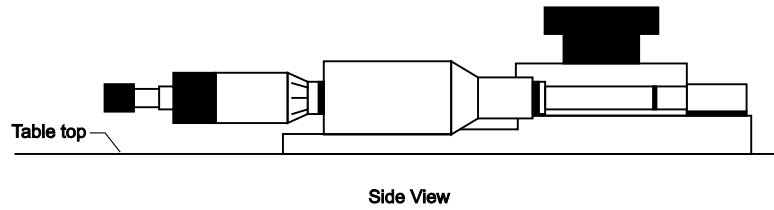
procedure in the current API RP 10B-2. Normally, two or more expansion molds will be filled with the same slurry for this type of testing.

4. Refer to Figure 3-1. Pour the slurry into the large hole near the outside of the top of the ring mold (fill hole) until the slurry exits the small hole (vent hole), opposite the large hole. This small hole is for venting air as the mold is filled.
 - If the slurry is very thick, tap or vibrate the mold to ensure the mold is completely filled.
 - If the slurry is too thick to pour freely, use a 60 ml syringe or modified standard syringe to transfer the slurry into the mold through the fill hole. To modify a standard syringe, cut off the tip of a 60 ml syringe and widen the opening to approximately 1/4 in. to 3/8 in. With the plunger inside the syringe, place the syringe into the thick slurry, slowly pull the plunger out to collect slurry inside the syringe, and eject it into the large hole of the mold. Repeat this procedure until the mold is filled completely.
5. With the micrometer closed, set the meter to zero by pressing 0 (zero).
6. Open the micrometer and place it on the smooth flat surface beside the mold. See Figure 3-2.
7. Measure the distance between the outside of the steel balls attached to each side of the split on the outer expansion ring (Figure 3-2) and record this distance. This measurement is the initial measurement.
8. Look through the fill and vent holes to check for changes in the height of the cement slurry.
 - If you observe such changes, readjust the micrometer so that the slurry is in its original location (does not rise in the fill or vent holes).
 - If you do not observe such changes, proceed to Step 9.
9. Record the measurement on the micrometer. This measurement is the initial measurement.



cccd1082

Figure 3-1 Circular Expansion Mold (P/N 100020342)



cccd1083

Figure 3-2 Micrometer (P/N 101204060)

3.3 Atmospheric Curing

Cure the sample at atmospheric pressure as follows:

1. Preheat a water bath to the test temperature.
2. Place the expansion mold filled with cement slurry into the water bath.
3. Cure the specimen for the specified length of time before taking the first expansion measurement.

3.4 Pressure Curing

1. Place the expansion mold filled with cement slurry into an autoclave (e.g., 2-cube autoclave, BP settling test autoclave, or other).
2. Fill the autoclave with water.
3. If the slurry has been preconditioned in an atmospheric or pressure consistometer, preheat the curing autoclave and the water inside to the same temperature at which the transfer is to be made. (This step is the same procedure used for preheated UCA or autoclave-cured compressive strength testing).
4. Pressurize and heat the water to test temperature in the same manner as for a UCA or autoclave-cured compressive strength test.
5. Apply pressure and increase the temperature to the final testing temperature. Cure at the test temperature and pressure for the length of time required to determine the first expansion measurement.
6. If the specimen was cured at or below 170°F (76.7°C), remove it and immediately measure the expansion.
7. If curing was at a temperature higher than 180°F (82.2°C),
 - decrease the temperature to between 170°F (76.7°C) and 180°F (82.2°C) the end of the curing period.
 - release the pressure on the autoclave, remove the mold, and place it into a preheated 170°F(76.7°C) water bath.
 - let the temperature of the specimen stabilize for approximately 30 minutes before determining the expansion measurement.

3.5 Measuring Expansion/Shrinkage



To help prevent the specimen from cooling enough to cause an erroneous measurement, remove only one mold at a time from the heated water bath and take the measurements very quickly.



Wear rubber or insulated rubber gloves to help prevent burns while handling hot molds.

Take an expansion/shrinkage measurement as follows:

1. Close the micrometer and set it to zero.
2. Open the micrometer and place it on a smooth, flat surface.
3. Remove the expansion mold from the water bath and place it on the smooth flat surface beside the micrometer.
4. If a spacer block was used, carefully remove it.



Do not expand the outer expansion ring while removing the spacer block.

5. With the micrometer, measure the distance between the outside of the steel balls using the same procedure you used to perform the initial measurement.



Because the cement is set, you do not need to be concerned with rising levels of cement (in contrast to the procedure for obtaining the initial measurement).

6. If you plan to take measurements at other time intervals, place the specimen into the curing bath or autoclave and continue curing the specimen at the test temperature and pressure conditions
7. Perform measurements for additional curing times in the same manner as the first expansion measurements.

3.6 Calibrating the Outer Expansion Ring

This calibration procedure should be performed annually. The resilience of the outer expansion ring should be such that when $1000\text{ g} \pm 1\text{ g}$ ($2.2046\text{ lb} \pm 0.002\text{ lb}$) is applied, the distance between the two steel measurement balls will increase by $2\text{ mm} \pm 0.3\text{ mm}$ ($0.0787\text{ in.} \pm 0.0118\text{ in.}$) without permanent deformation.

Refer to Figure 3-3.

1. Secure the outer expansion ring so that it hangs from a stationary, level surface. The two steel measurement balls must be at a 90° angle as shown below.
2. Apply $1000\text{ g} \pm 1\text{ g}$ ($2.2046\text{ lb} \pm 0.002\text{ lb}$) to the ring. The load must be applied perpendicular (90°) to the gap.
3. Observe and measure the distance between the steel measurement balls.
4. Repeat this measurement at least three times. Calculate the average with a standard deviation of 0.05 mm (0.002 in.). If this calibration fails, contact Fann Instrument Company.

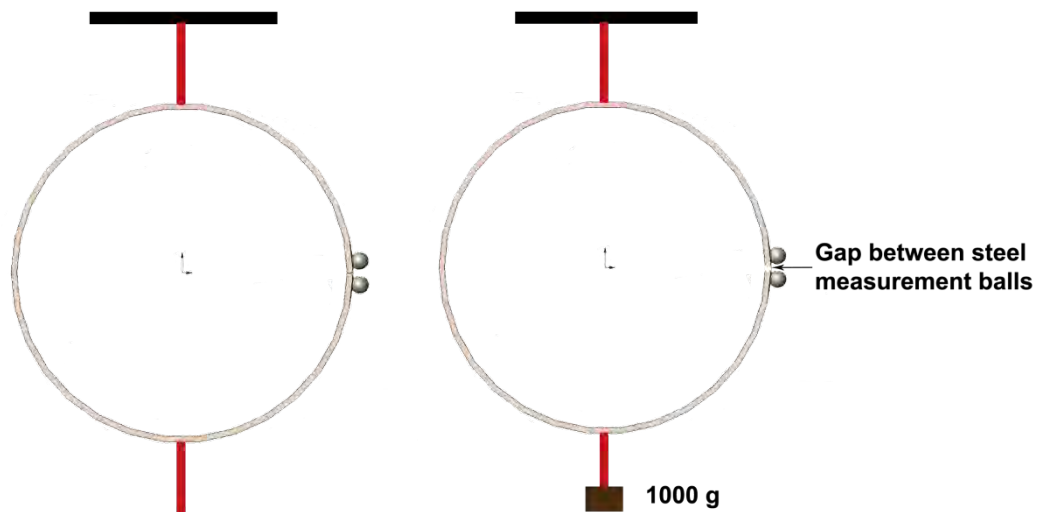


Figure 3-3 Outer Expansion Ring Calibration

4 Test Analysis

4.1 References

- API Recommended Practice on Determination of Shrinkage and Expansion of Well Cement Formulations at Atmospheric Pressure, API RP 10B-5
- API Recommended Practice for Testing Field Cements, API RP 10B-2

4.2 Calculations for Percent of Expansion/Shrinkage

The percent of expansion/shrinkage can be calculated using one of the following equations. A positive value indicates expansion; a negative value indicates shrinkage.

4.2.1 For measurement in inches:

$$\% \text{ Expansion} = (M_t - M_i) \times 9.095$$

Where:

M_t = micrometer measurement in inches at curing time

M_i = initial micrometer measurement in inches

4.2.2 For measurement in millimeters:

$$\% \text{ Expansion} = (M_t - M_i) \times 0.358$$

Where:

M_t = micrometer measurement in millimeters at curing time

M_i = initial micrometer measurement in millimeters



Because of the small distance between the measurement balls, no correction is needed for extrapolating the initial room temperature measurements of the mold to the actual test temperature measurements if cured at 170°F (76.7°C) or less. The theoretical correction for the metals used in the molds is only 0.005% for each 100°F (55.6°C) above the initial room temperature measurement.

4.3 Correction Factor for Curing Temperatures Greater than 170°F

When the mold is kept at testing temperature of 170°F (76.7°C) or less as described earlier, the correction factor is not used. Samples cured at higher temperatures and pressure must have the mold and specimen held in a water bath at 170°F (76.7°C) before determining the measurement. When you are curing a specimen at temperatures greater than 170°F (76.7°C), you must subtract a correction factor from the percent of expansion calculated above, as indicated by the following equation:

$$\% \text{ Expansion} - \% \text{ Correction} = \text{Corrected \% Expansion}$$

To calculate the % correction factor, use one of the following equations.

4.3.1 For temperature measurements in °F:

$$\% \text{ Correction} = (T_c - 170) \times 0.00033$$

Where: T_c = curing temperature in °F

4.3.2 For temperature measurements in °C:

$$\% \text{ Correction} = (T_c - 76.67) \times 0.000594$$

Where: T_c = curing temperature in °C



This correction is only an approximation. When the expansion values are small, it may be necessary to perform the test using slurries with and without expansive material. Compare the expansion properties of the slurry to determine if there is expansion.

5 Parts List

Table 5-1 Expansion/Shrinkage Test Kit, P/N 205814, Rev C

| Part No. | Quantity | Description |
|-----------|----------|-------------------------------------|
| 100020342 | 1 | CIRCULAR EXPANSION MOLD (RING MOLD) |
| 101204060 | 1 | MICROMETER AND GUIDE BASE |
| 101443617 | 1 | INSTRUCTION MANUAL |

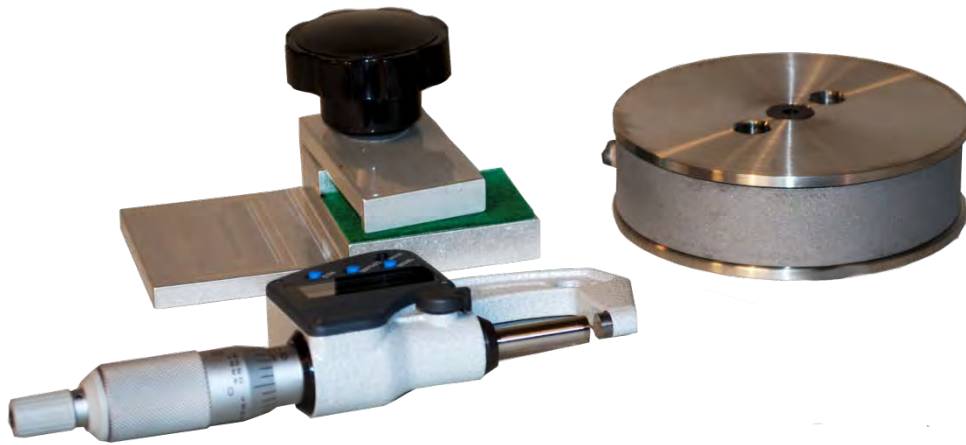


Figure 5-1 Expansion/Shrinkage Test Kit

Table 5-2 Circular Expansion Mold Assembly, P/N 100020342, Rev B

| Item No. | Part No. | Quantity | Description |
|----------|-----------|----------|------------------------------------------------|
| 1 | 100020343 | 1 | PLATE, TOP |
| 2 | 100020344 | 1 | PLATE, BOTTOM |
| 3 | 100020345 | 1 | INNER STATIONARY RING |
| 4 | 100020346 | 1 | OUTER EXPANSION RING |
| 5 | 100028148 | 1 | SCREW, FLAT HEAD CAP, 14-20 NC X 1, HEX SOCKET |
| 6 | 102304066 | 1 | SPACER BLOCK |

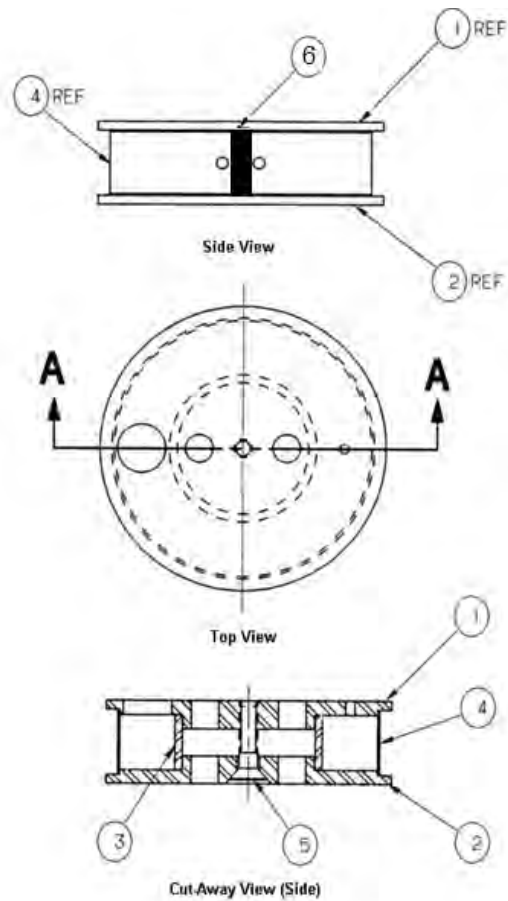


Figure 5-2 Circular Expansion Mold Assembly Drawing

Table 5-3 Micrometer and Base Assembly, P/N 101204060, Rev B

| Item No. | Part No. | Quantity | Description |
|----------|-----------|----------|------------------------------------------------------------------------------------------------|
| 1 | 101204063 | 1 | CLAMP, MOUNT, MICROMETER, CIRCULAR EXPANSION MOLD |
| 2 | 101204061 | 1 | BASE, MOUNT, MICROMETER, CIRCULAR EXPANSION MOLD |
| 3 | 100032312 | 1 | KNOB, PLASTIC, FLUTED, BLACK, DK-26, REID |
| 4 | 100137775 | 1 | MICROMETER, DIGITAL, RANGE 0-1 INCH, RESOLUTION 0.00005 INCH/0.001 MM, LCD READOUT, SERIES 293 |

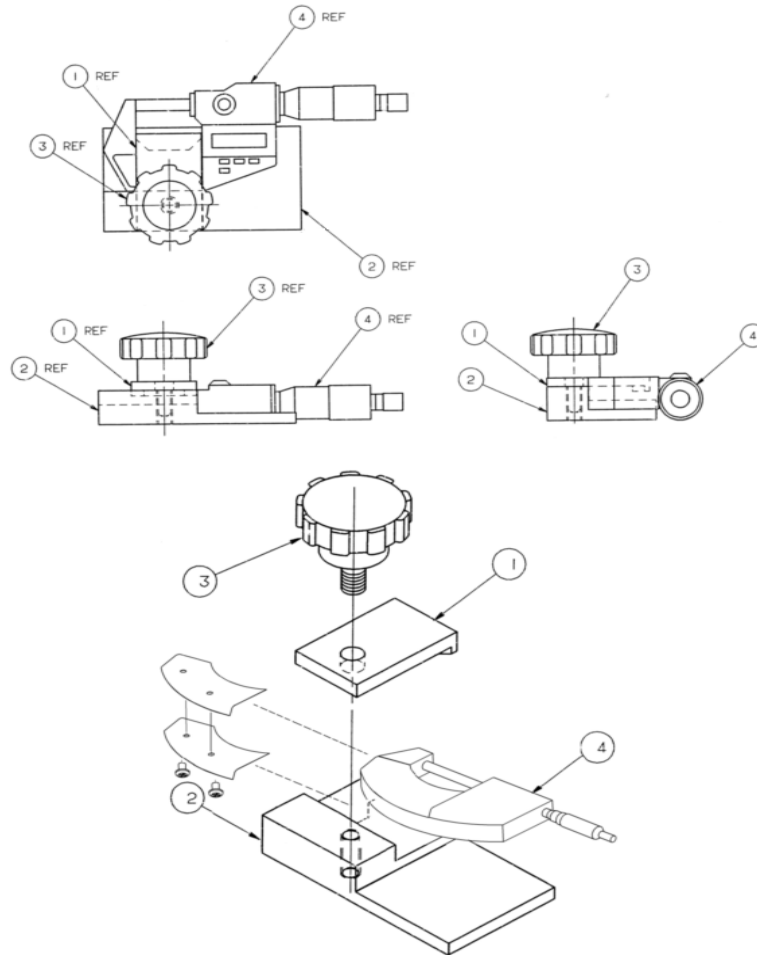


Figure 5-3 Micrometer and Base Assembly Drawing

6 Warranty and Returns

6.1 Warranty

Fann Instrument Company warrants only title to the equipment, products and materials supplied and that the same are free from defects in workmanship and materials for one year from date of delivery. THERE ARE NO WARRANTIES, EXPRESS OR IMPLIED OF MERCHANTABILITY, FITNESS OR OTHERWISE BEYOND THOSE STATED IN THE IMMEDIATELY PRECEDING SENTENCE. Fann's sole liability and Customer's exclusive remedy in any cause of action (whether in contract, tort, breach of warranty or otherwise) arising out of the sale, lease or use of any equipment, products or materials is expressly limited to the replacement of such on their return to Fann or, at Fann's option, to the allowance to Customer of credit for the cost of such items. In no event shall Fann be liable for special, incidental, indirect, consequential or punitive damages. Notwithstanding any specification or description in its catalogs, literature or brochures of materials used in the manufacture of its products, Fann reserves the right to substitute other materials without notice. Fann does not warrant in any way equipment, products, and material not manufactured by Fann, and such will be sold only with the warranties, if any, that are given by the manufacturer thereof. Fann will only pass through to Customer the warranty granted to it by the manufacturer of such items.

6.2 Returns

For your protection, items being returned must be carefully packed to prevent damage in shipment and insured against possible damage or loss. Fann will not be responsible for damage resulting from careless or insufficient packing.

Before returning items for any reason, authorization must be obtained from Fann Instrument Company. When applying for authorization, please include information regarding the reason the items are to be returned.

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