

HI-TEMP® PENETRANT INSPECTION SYSTEM



PRODUCT INFORMATION

Description: Sherwin Incorporated's Hi-temp® Penetrant System is designed to work at temperatures above which ordinary penetrants are ineffective. Three products comprise the system: K-019 Remover, K-017 Penetrant, and D-350 Developer.

Special Features: The Hi-temp® Penetrant System is effective at higher temperatures. Using the system can *reduce inspection costs*; waiting times are reduced.

Temperatures rise during welding processes. They also rise under normal operating conditions for certain kinds of equipment, such as pressure vessels, or simply, when inspection work is done in the sun. Often, before moving to a new piece, welders must wait for the current piece to cool before inspecting it. Similarly, some fabrication processes require as much as 24 hours between steps because parts must cool enough to allow inspection with ordinary penetrants. Waiting for parts to cool — generally to less than 140°F — increases processing time, and production costs.

Heat actually enhances the Hi-temp® Penetrant System's performance. Heat drives contaminants from flaws; and heat-expanded flaws trap more penetrant, giving stronger indications after developer is applied. Additionally, Hi-temp® K-017 Penetrant requires less dwell time than ordinary penetrants in order to locate equivalent sized flaws. Finally, Hi-temp® K-017 Penetrant is water washable, so removing excess penetrant does not require a "remover" under most conditions, and post-cleaning of spillage and over-spray is easy.

The Hi-temp® Penetrant System reduces processing time and production costs.

Container Sizes:
case of 12 spray cans
one-gallon cans
case of 4 one-gallon cans
five-gallon pails

Basic Instructions: (These instructions describe the basic process. They may be amended by the user to comply with applicable specifications and/or inspection criteria provided by the contracting agency.)

1. **Cleaning:** Cleaning may be unnecessary prior to applying Hi-temp® K-017 Penetrant because the penetrant itself is highly detergent and dissolves organic contaminants, especially on heated surfaces. In addition, at higher temperatures certain contaminants, such as oils, greases, and waxes, will liquify and be easily displaced, while other contaminants, such as water and solvents, will evaporate. Even so, it may be necessary to use Hi-temp® K-019 Remover before applying the penetrant.
 - a. **K-019 Application:** Spray or brush Hi-temp® K-019 Remover on the surface and allow to dwell for 1 to 4 minutes; use shorter times for higher temperatures and less contamination.

Wipe K-019 Remover from the surface with clean, dry cloth or paper towels. Then, wipe with water saturated towels. A final wipe with dry towels in order to speed drying may be required at lower temperatures.

Repeat the application/wiping procedure if necessary. Wire brushing may be required to remove scale or other deposits. Paint is generally removed with a torch.
 - b. **Drying:** The part must be dry before applying Hi-temp® K-017 Penetrant. Hotter parts dry more quickly than cooler parts.
2. **Apply Penetrant:** Spray or brush Hi-temp® K-017 Penetrant on a limited area. It is important that the area to which the penetrant is applied not be too large so processing can be completed within penetrant and developer dwell time restraints. The acceptable area size will vary with inspection temperatures, part geometry, and operator experience.

The penetrant must dwell on the part in order to penetrate surface flaws. At higher temperatures, penetration occurs more quickly. The following table suggests how K-017 dwell times vary with temperature. Allowances must be made for contamination levels and flaw sizes.

225° - 350°F	30 seconds to 1 minute
175° - 225°F	1 - 2 minutes
125° - 175°F	2 - 3 minutes
75° - 125°F	3 - 10 minutes
50° - 75°F	10 - 30 minutes

3. **Remove Excess Penetrant:** It is important that all excess penetrant be removed, otherwise the developer step may be adversely affected.

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- a. **Wipe Surface:** Remove as much **Hi-temp® K-017 Penetrant** as possible using paper or soft, clean cloth towels to wipe the surface.
- b. **Apply Remover:** Use **Hi-temp® K-019 Remover** to clean remaining penetrant from the surface. **K-019** may be directly sprayed in a thin coat and immediately wiped from the surface. If part surfaces are smooth, using **K-019** may be unnecessary. In either case, as a final step, the part should always be wiped with a water saturated towel or cloth to remove the last traces of penetrant. Immediately follow water wipe with a dry wipe.

Note: The surface must be completely free of both penetrant and remover, or **Hi-temp® D-350 Developer** will not lay in an even coat. Generous water usage is suggested.

- c. **Drying:** Use paper or cloth toweling to dry the part's surface thoroughly. Special drying time before applying developer to heated parts should not be required.
4. **Apply Developer:** Two non-aqueous developers may be used with the **Hi-temp®** system: **D-100**, a conventional developer which is recommended for temperatures from 50° - 250°F, and **D-350** which is recommended for temperatures between 175°F and 350°F. When temperatures exceed 175°F, and the more they approach 250°F, the more **D-350** is preferred. (A separate information sheet is available for **D-100**.)

The developer should be sprayed on the part surface from a distance of 6-8 inches immediately after the excess penetrant has been removed and the part has dried. Apply a thin even coat over the entire surface to which **K0-17 Penetrant** was originally applied; two or three thin coats are preferred to a single, heavy coat. If penetrant removal is incomplete, the developer will not go evenly on the part.

5. **Observe Indications:** Observe the surface for defect indication formation while the developer is applied.

At high temperatures, flaw indications appear almost instantly. Color depth is greatest within a few seconds after applying developer. Therefore, final surface examination should begin within a minute or two after developer application.

At high temperature, developed indications have a tendency to spread and lose their definition more rapidly. Moreover, some color fading with extended development times must be anticipated. Surface examination should be completed as quickly as practical, and within ten or fifteen minutes.

Red lines usually indicate cracks or lack of fusion. Red dots in a line or curved pattern usually indicate a tight crack. And, scattered dots usually denote porosity.

General Information: Do not attempt to inspect large areas that cannot be processed quickly. Permitting the penetrant to dwell longer than maximum times produces color degradation and excess vapors. Also, penetrant indications lose their resolution and tend to fade when exposed to heat.

At high temperatures, **D-350 Developer** may be removed by simple brushing. However, at lower temperatures, complete removal may require wiping with towels dampened with water or **K-019 Remover**.

PRECAUTIONARY INFORMATION

All **Hi-temp® Penetrant System** products —**K-017, K-019, D-350, and D-100**— should be used with adequate ventilation and away from sparks and flame, especially when these products are applied to heated surfaces.

D-350 and **D-100** are flammable. Their vapors may cause drowsiness or unconsciousness. Victims should be removed to fresh air; commence CPR if necessary; seek medical attention. In the event of a **D-350** or **D-100** spill, eliminate all sources of ignition, stand-by with fire extinguisher, and contact authorities.

Be careful not to place spray cans containing **Hi-temp® Penetrant System** materials on heated surfaces; heated containers may explode. Never burn, puncture, or heat spray cans: store at less than 120°F; keep out of direct sun.

Wear protective clothing and equipment. Eye contact will cause severe pain and may result in injury. Flush eyes with water and seek immediate medical attention.

K-017 and **K-019** have strong detergent properties and may cause severe skin irritations. Promptly remove from skin by washing with water. Do not wear clothes contaminated with **Hi-temp® Penetrant System** products.

Read and follow safety instructions presented on container labels and on the manufacturer's Material Safety Data Sheets.

QUESTIONS AND ANSWERS ABOUT USING THE HI-TEMP® SYSTEM

Do Hi-temp® penetrants meet sulfur and halogen restrictions of specifications such as ASME Codes III and V, RDT F3-6T, and NAVSHIPS 250-1500?

Definitely. Analyses by a recognized laboratory yielded the following determinations, well below the 1.00% (10,000 ppm) and 0.50% (5,000 ppm) limits:

Hi-temp® Material	Halogens (ASTM D808)	Sulfur (ASTM D129)
K-017Dye Penetrant	0.002% (20 ppm)	0.02% (200 ppm)
K-019Remover	0.002% (20 ppm)	0.01% (100 ppm)
D-100 Developer	0.002% (20 ppm)	0.01% (100 ppm)
D-350 Developer	0.005% (50 ppm)	0.01% (100 ppm)

Complete certification available upon request.

Does the Hi-temp® Dye Penetrant process conform to Article 6, paragraph T-660, "Qualification of Procedures for Nonstandard Temperatures" of ASME Code Section V, as well as comparable paragraphs in Section III and RDT F3-6T?

Yes. An independent laboratory confirmed that K-017Visible Penetrant at elevated temperatures performs as well as conventional visible dye penetrants perform at ambient temperature. After tests, the laboratory concluded that the sensitivity yield of K-017Dye Penetrant with K-019Remover and D-100 Developer on surfaces maintained at 250°F was equivalent to the Mil-I-25135 Group I "Standard" on ambient (about 80°F) surfaces. (Aluminum block comparators, cut into two sections, were used in these tests.)

Similar tests with equally good results have been performed on surfaces of 350°F using Hi-temp® K-017Dye Penetrant and K-019Remover, but substituting D-350 Developer for D-100.

What are the provisions for using the Hi-temp® Penetrant System on NAVSHIPS contracts?

The system is now used in the NAVSHIPS program. Contractors can arrange to use the Hi-temp® process by demonstrating the system's efficacy under a particular contract. The U.S. Military has shown substantial interest in processes which improve performance and lower costs.

In a multi-pass weldment situation, what is the effect of residues from Hi-temp® products on the subsequent weld layer?

In one NAVSHIPS approval program, tests were made where heavy residues of all material were purposely left between weld layers. Subsequent microsectioning and examination revealed no harmful effect.

What are the personal hazards when using the Hi-temp® System?

Wear suitable gloves for protection against contact with heated surfaces during wipe-off step.

At higher temperatures, some irritating vapors will be produced. Where practical, a fan should direct the vapors away from the technician, and, to minimize any adverse effects, small part segments should be inspected at a time. Considering the small area inspected and the brief penetrant dwell before wipe-off—30 to 60 seconds—vapor quantities will be minimal.

In addition, K-017and K-019have strong detergent properties and should immediately be flushed from skin and eyes with fresh water.

What about the fire hazard?

Again, very small areas and quantities of material are involved. For example, less than one half ounce of Hi-temp® K-017 Penetrant is required to paint 20 linear feet of 1.5 inch wide weldment. Such small quantities should not alarm safety engineers. Also, Hi-temp® K-017 Penetrant and Hi-temp® K-019 Remover have flash points in the 400°F range. Both developers, D-100 and D-350, are invariably applied from pressurized spray cans, so, even though they are alcohol based, quantities of exposed flammable material in the area are negligible.

The greatest personnel risk would be from leaving a pressurized can on a heated surface.

Why are there two developers, D-100 and D-350? What is the difference between the two?

D-100 Developer, Sherwin Incorporated's standard, normal temperature developer, is effective with the Hi-temp® process on surfaces as hot as 250°F. However, above 250°F, the developer's white particles tend to flake from the surface, so the effective limit of D-100 Developer is 250°F.

With the 350°F preheat temperature required for most multi-pass welds, there is a critical need for a process effective at this higher temperature. D-350 Developer fills this need. With D-350 Developer, the **Hi-temp®** System performs at temperatures slightly in excess of 350°F; D-350 adheres to the surface at this higher temperature.

When should D-100 be used and when should D-350 be used?

The recommendation is to use D-100 Developer from normal temperatures to 250°F, and D-350 from 175°F to 350°F.

There is an overlap between the two developers. Which should be used at, say, 200°F?

If D-100 is already being used with Sherwin Incorporated's normal temperature process, continue using D-100. Otherwise, D-350 is preferred.

Can D-350 Developer be used at temperatures lower than 175°F, say as low as 70°F?

D-350 is not recommended for use at temperatures lower than 175°F. At lower temperatures, D-350 dries more slowly. Also, the particles are more adhering at lower temperatures and require greater effort to remove upon completion of the inspection process. Removing D-350 requires wiping with water dampened toweling.

Is the Hi-temp® System effective at normal temperatures?

Yes. **Hi-temp®** K-017Dye penetrant with K-019 Remover and D-100 Developer do an excellent job of finding cracks at normal and even low temperatures. K-017 does a better job of showing the shallow flaw than conventional penetrants, but the penetrant is not as fluid at lower temperatures. Thus, penetration time should be longer. Also, in a manual wipe (Group I) method, at lower temperatures, the penetrant removal step is too laborious for routine use.

Can chemical processing plants or refineries gain from using the Hi-temp® System?

Absolutely. Such facilities circulate hot fluids. Leaks occur in equipment which produces revenue of hundreds of dollars per hour, or more. Allowing the equipment to cool to 125°F in order to pinpoint and repair leaks as is required by conventional penetrants may take hours. Finding a leak and verifying the repair without cooling saves valuable production time.

Why is the Hi-temp® penetrant dwell time so short —30 to 60 seconds— when conventional penetrants require 10 minutes?

At elevated temperatures, such as 250°F, molecular movement greatly speeds penetration.

If K-017 Penetrant dwelled on a 250°F surface for 10 minutes, what would happen? Would the penetrant volatilize? Would the color be destroyed?

There was no discernible difference between sections of an aluminum comparative test block maintained at 250°F when K-017 dwelled on one section for a full 11 minutes, and on the other section for only 60 seconds. K-017 on both sections was equally fluid and easily removed. Color depth was identical. Sensitivity was the same. The longer dwell time seems to have little effect, either harmful or beneficial. However, 15 minutes is the suggested maximum penetrant dwell time at higher temperatures.

How are developed flaw indications affected by high temperatures?

At high temperatures, flaw indications develop almost instantly. The initial deep red color of an indication is greatest within a few seconds after developer is applied. After a few minutes, the indication tends toward an orange-red shade. However, even after 30 minutes with surfaces maintained at 250°F, flaw marks are still pronounced and well defined with good color contrast.

Do Hi-temp® materials come in spray cans as well as gallons and pails?

Yes. **Hi-temp®** K-017 Penetrant, K-019 Remover, and both D-100 and D-350 Developers are packaged in gallons, pails, and spray cans.