

# purposes and types of fill

## COOLING TOWER HEAT TRANSFER

### Purpose of Fill

The rate of heat transfer in the spray-type cooling tower shown as **Figure 1** in *Cooling Tower Performance, Basic Theory and Practice* — available from SPX Cooling Technologies — was indicated to be a function of the total water surface that the pressurized spray system was capable of exposing to the mass of flowing air. This relationship between water surface exposure and heat transfer rate is intrinsic to all types of towers, regardless of the type of water distribution system utilized. The more water surface exposed to given flow of air — the greater will be the rate of heat transfer.

For a specific heat dissipation problem, however, the rate at which enthalpy will be exchanged is important only in the sense that it allows the designer to predict a finite total exchange of heat — with the total being a function of the period of time that the air and water are in intimate contact. Within psychrometric limits, the longer the contact period — the greater the total exchange of heat — and the colder the cold water temperature.

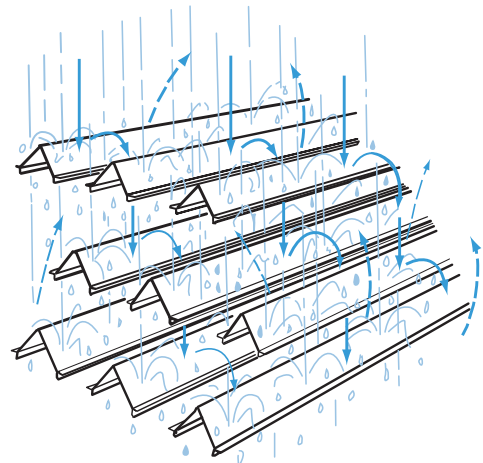
In the spray-type cooling tower, total time of air-water contact can only be increased by increasing the height of the cooling tower, causing the water to fall through a greater distance. Given a tower of infinite height, the cold water temperature produced by that tower would equal the incoming air's wet-bulb temperature, and the leaving air temperature would equal the incoming hot water temperature (these are the psychrometric limits previously mentioned).

Obviously, a cooling tower of infinite height would cost an infinite amount of money. More practically, structural limitations would begin to manifest themselves within the first feeble steps on the road to that infinite height. Early cooling tower designers quickly discovered these limitations, and devised the use of "fill" as a far better means of increasing not only the rate of heat transfer but its amount as well.

Although cooling tower fill is often acceptably referred to as a heat transfer surface, such terminology is not true in its strictest sense. The heat transfer surface in the classic cooling tower is actually the exposed surface of the water itself. The fill is merely a media by which more water surface is caused to be exposed to the air (increasing the rate of heat transfer), and which increases the time of air-water contact by retarding the progress of the water (increasing the amount of heat transfer).

### Types of Fill

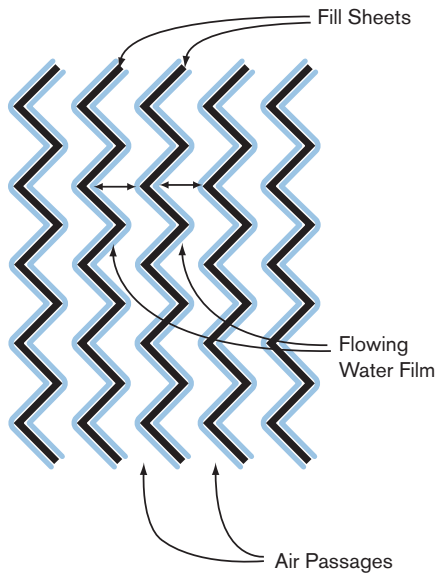
The two basic types of fill utilized in present day cooling towers are splash-type — **Figure 1** and film-type — **Figure 2**. Either type of fill may be used in towers of both crossflow and counterflow configuration, positioned within the towers as shown in **Figure 3** and **Figure 4** respectively. Both types of fill exhibit advantages in varied operating situations, assuring that neither type is likely to endanger the continued utilization of the other. Offsetting cost comparisons tend to keep the two types competitive, and it is usually operational advantages peculiar to a specific situation that tip the scales of preference. Therefore, specifiers are cautioned against exclusion of either type, unless the reasons for doing so are overriding.



**FIGURE 1A**

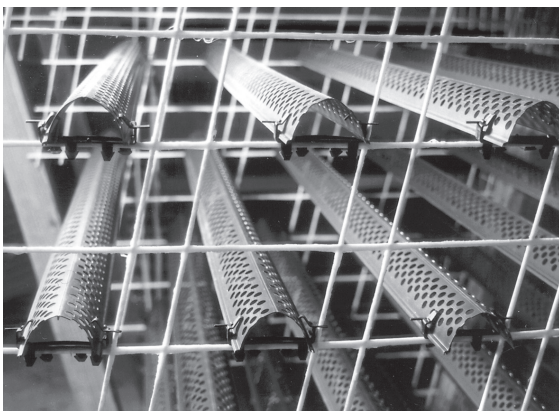
Splash-fill causes the flowing water to cascade through successive elevations of parallel "splash bars." Equally important is the increased time of air-water contact brought about by repeated interruption of the water's flow progress.





**FIGURE 2A**

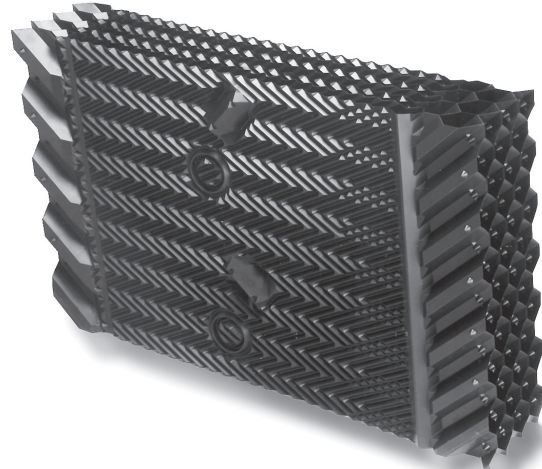
Since the movement of water within a cooling tower is essentially vertical, splash-fill obviously must be arranged with the wide dimension of the splash bars situated in a horizontal plane. Otherwise, maximum retardation and break-up of the water could not be realized. Consequently, splash-fill provides the least opposition to airflow in a horizontal direction, which accounts for the fact that splash-fill is seldom used in counterflow cooling towers.



**FIGURE 1B** *Splash fill installed*

Because of the water dispersal that takes place, splash-fill cooling towers are far more forgiving of the poor initial water distribution which can result from clogged or missing nozzles, than are film-fill cooling towers. The splashing action effectively redistributes the water at each level of splash bars. This is not to say that design of the water distribution system for a splash-fill cooling tower is given little thought. The mere fact that all types of water distribution systems are utilized for both splash and film-fill towers makes their standardized development of prime importance, and both types of cooling towers, of course, benefit from this development effort. The splash-fill cooling tower, however, is less affected when water-borne debris causes a deviation from the normal water flow patterns.

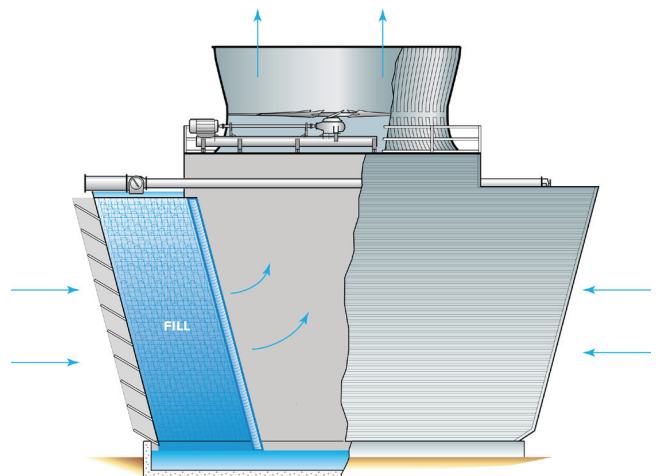
Although very forgiving of "dirty" water and imperfect distribution, splash fills do require stable support systems — **Figure 7** — to prevent long-term performance degradation. If the splash bars are not maintained in a level configuration, flowing water will "channel" to the low end of the fill, leaving areas devoid of water flow where little or no heat transfer can occur. Given a choice of flow paths, air will always concentrate its flow in regions of least water curtain density where it encounters minimum resistance.



**FIGURE 2B** *Crossflow film fill with integral louvers and eliminators*

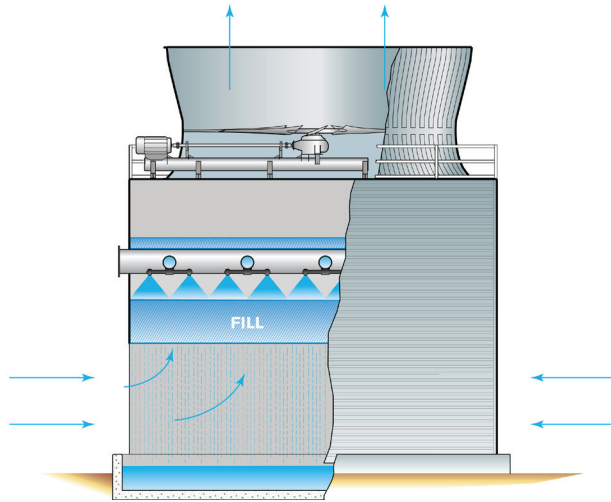
Prominent usage of splash-fill occurs in crossflow cooling towers, where the full-height air inlet face and open nature of the fill permits relatively easy visual inspection of the water flow pattern and the condition of the fill. In such cases, diagnosis of fill problems is greatly simplified.

Film-fill has gained prominence in the cooling tower industry because of its ability to expose greater water surface within a given packed volume. Approximately half of the fill used in crossflow cooling towers, and virtually all that which it utilized in counterflow cooling towers is film-type. It is equally effective in either type cooling tower.



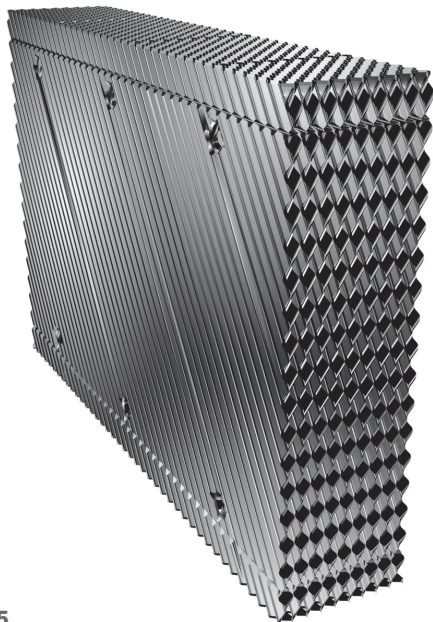
**FIGURE 3** *Crossflow Design*

As can be seen in **Figure 2**, water flows in a thin “film” over vertically oriented sheets of fill which are usually spaced approximately 3/4” apart. These sheets are usually molded into corrugated or “chevron” patterns – **Figure 2B** – to create a certain amount of turbulence within the air stream, and to further extend the exposed water surface. The fill pack indicated in **Figure 5**, for example, is manufactured in a “cross-corrugated” configuration, with the contact points of the corrugated “hills” providing the proper spacing. Other shapes will include regular protrusions to maintain spacing.



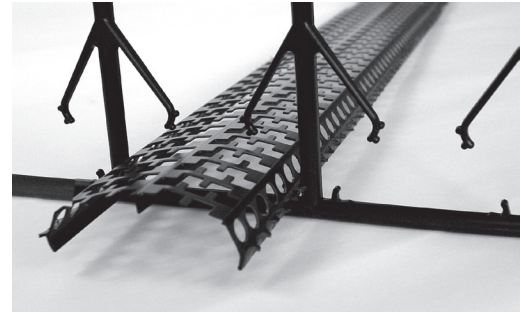
**FIGURE 4** Counterflow Design

In the majority of operating cases, the use of film-fill enables cooling tower manufacturers to achieve a given amount of cooling within a smaller cooling tower than would be required if splash-fill were utilized. For reasons of expediency, therefore, and to limit inventory management, many manufacturers have ceased offering splash-fill, and their literature extolls only the virtues of film-fill. Because SPX Cooling Technologies continues to offer both types of fill, this paper will discuss some negative aspects of film-fill in an effort to promote a balanced viewpoint.



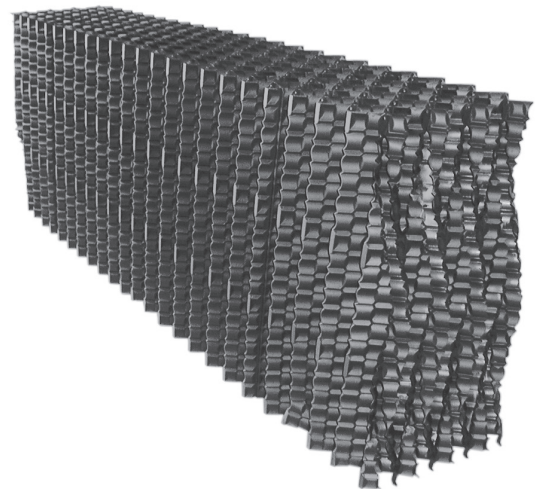
**FIGURE 5**

Unlike splash-fill, film-fill affords no opportunity for the water to redistribute itself during its vertical progress. Consequently, uniformity of the initial water distribution at the top of the fill is of prime importance, as is vigilant maintenance of the water distribution system. Areas deprived of water will become unrestricted paths for maximum airflow, and thermal performance will degrade. This aspect of film-fill is frequently given less than adequate thought in the upgrading of existing cooling towers, resulting in disappointment on the part of the owner.



**FIGURE 6** Polypropylene splash fill support grid

The narrow passages afforded by close spacing of fill sheets makes film-fill very sensitive to water quality. High turbidity, leaves, debris, or the presence of algae, slime, or a fatty acid condition, can diminish passage size and affect heat transfer efficiency. In a number of cases, extensive plugging has occurred requiring emergency shutdown for thorough cleaning and/or repairs. This close spacing also precludes visual inspection of the fill's inner passages so, by the time a plugging situation becomes visually apparent, the condition is likely to have become extreme. Recent film-fill developments have created low-clog, open, angular cross-corrugations designs – **Figure 7** – that allow debris and biological growth foulant to pass, while providing maximum surface area and turbulence to develop efficient heat transfer. Texturing creates thermal capability improvement with little effect on fouling.



**FIGURE 7**

In addition to requiring uniform initial water distribution, film-fills are also somewhat unforgiving of spotty air distribution. Structural members which block initial air entry can measurably disrupt air distribution (and thermal performance) for a considerable distance downstream of the obstruction. Consequently, film-fill is as sensitive as splash-fill to the method and adequacy of support.

## Recommendation

Where relatively “clean” water will be circulated over the tower, and good maintenance procedures will prevail, either film-fill or splash-fill may be used with equal confidence. This will be the expected condition in the majority of normal applications. Conversely, where appreciable contamination of the circulating water is anticipated, only splash-fill should be considered. Typical industries of concern would be food processing, dairy, hydrocarbon processing, steel production and foundries, paper processing, ammonia stripping, and the processing of soaps and cosmetics. Beyond these typical industries, any tower which will be required to operate in a dusty or wooded environment, or whose make-up supply will come from unclarified water, is a candidate for splash-fill. Where doubt exists, your nearest Marley cooling tower representative should be contacted for guidance.

## Key Features of Film Fill

- Greater cooling capacity in a given space
- Low-clog designs available
- Available in bottom supported or hanging designs
- FM approval available
- Crossflow and counterflow designs
- Integral louvers and eliminators available in crossflow design.
- High-temperature designs available
- Single-piece, full-height counterflow designs available

## Key Features of Splash Fill

- Ideal in “dirty water” applications
- Far more forgiving of poor water distribution caused by clogged or missing nozzles
- Water easily redistributes itself
- Ideal in dusty or wooded environments
- Easy maintenance
- Long service life
- High-temperature designs available
- Designs available for heavy ice loads



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