SEAWATER DESALINATION BY LARGE MULTISTAGE FLASH PLANTS

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Contents

Summary

A concise account of experience with MSF desalination plants in the Emirate of Abu Dhabi is given. Careful examination of the various issues, based on long experience, gave rise to certain thoughts which have been shared with all those concerned, with improvement of performance of existing plants and with future design. A large plant of six units, each of 12.7 MGD capacity, incorporating several improvements based on our past experience, has been recently commissioned. There are still many gray areas in this process, and they demand thorough investigation; maybe experimentally in an adequate instrumented pilot or production unit. The following points are worthy of particular attention.

- To improve evaporation rate by maintaining proper hydrodynamics in a flash stage, which can be achieved by modification in the interstage orifices and internal weirs.
- To reduce liquid entrainment with improved demisters and splash plates.
- To cut down shell side corrosion with more efficient venting.
- To evaluate properly the effect of non-condensables on the rate of heat transfer.
- To study thoroughly the stability of the MSF plants through improved models, which may lead to better designs and control.

As a result of these continuing investigations employing state-of-the-art techniques of control, identification, estimation, fault diagnosis, artificial intelligence, expert systems etc., it is expected that an intelligent integrated system of plant-wide automation and process care will gradually evolve. This should be of immense service to the desalination industry whose role in supporting life on our planet in general, and in our region in particular, cannot be overemphasized.

1. Introduction

A review of some important aspects of large-scale multistage flash (MSF) seawater desalination plants is presented. It is based on operational experience with such plants in the Emirate of Abu Dhabi in the United Arab Emirates (UAE) over nearly a quarter century. It discusses certain factors which influence plant performance, availability and economy in the light of the methods of current practice based on observations, the analysis carried out and the insight gained, over a long period of operational experience. Arising from this discussion are some suggestions for future directions for research, design and development of MSF plants with the long term objective of rendering them robust, reliable, and economical. Another key factor for the achievement of this objective is intelligent automation for plant-wide measurement, monitoring, assessment, and on-line optimization, control, fault diagnosis, and care.

2. Large Scale Seawater Desalination in Abu Dhabi, UAE

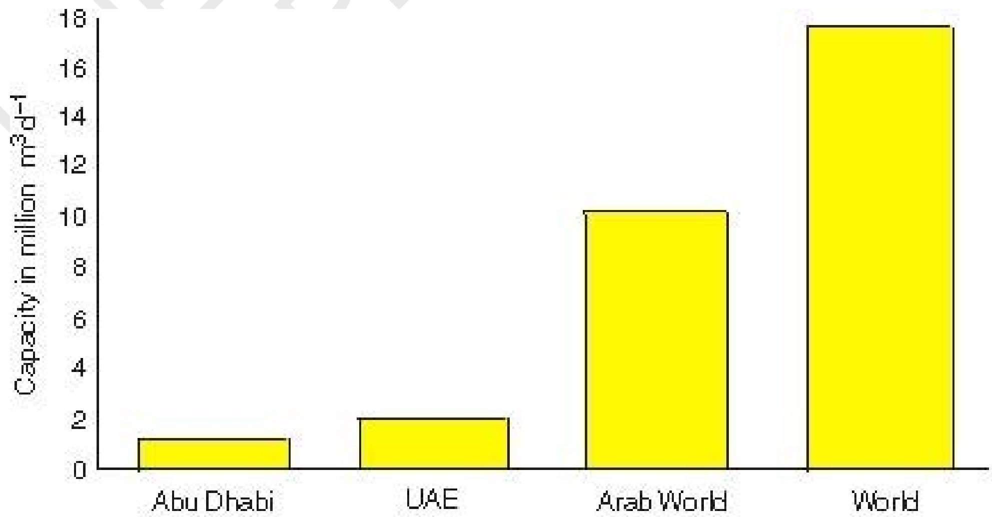

Figure 1. Installed seawater desalting capacity - regional and global.

The phenomenal transformation of Abu Dhabi over the past quarter century into a comfortable modern state is due mainly to the development of potable water resources by seawater desalination. Today, the UAE is one of the leading nations of the world in the practice of seawater desalination. Figure 1 shows the relative capacities of Abu Dhabi, the UAE and the Arab World, in relation to the whole world. Figure 2 illustrates the development of desalination capacity in Abu Dhabi since 1970. The dominance of plants based on the principle of MSF may be seen from Figure 3.

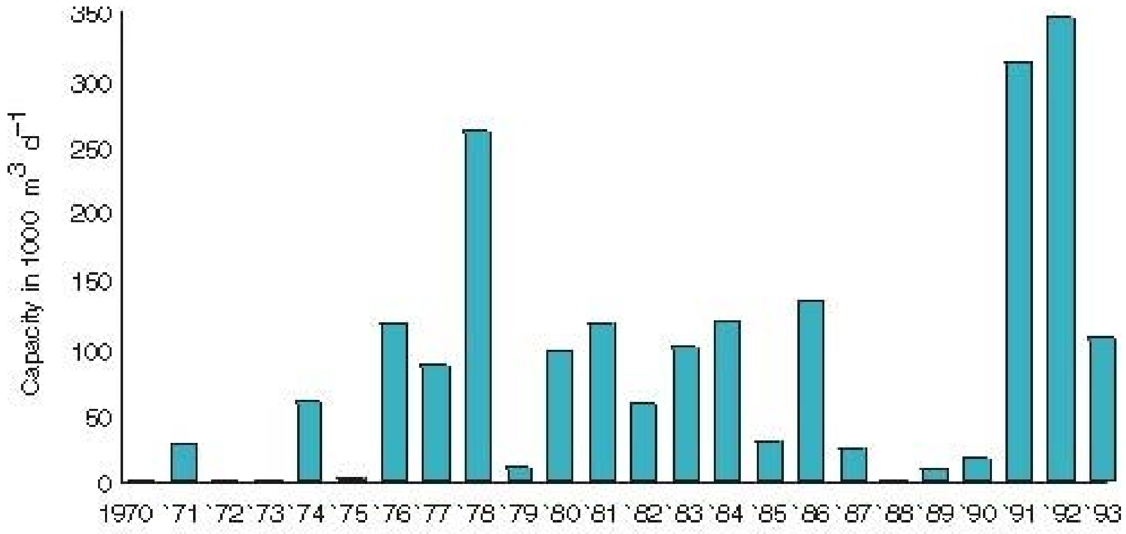

Figure 2. Installed seawater desalting capacity during 1970-93 in the UAE.

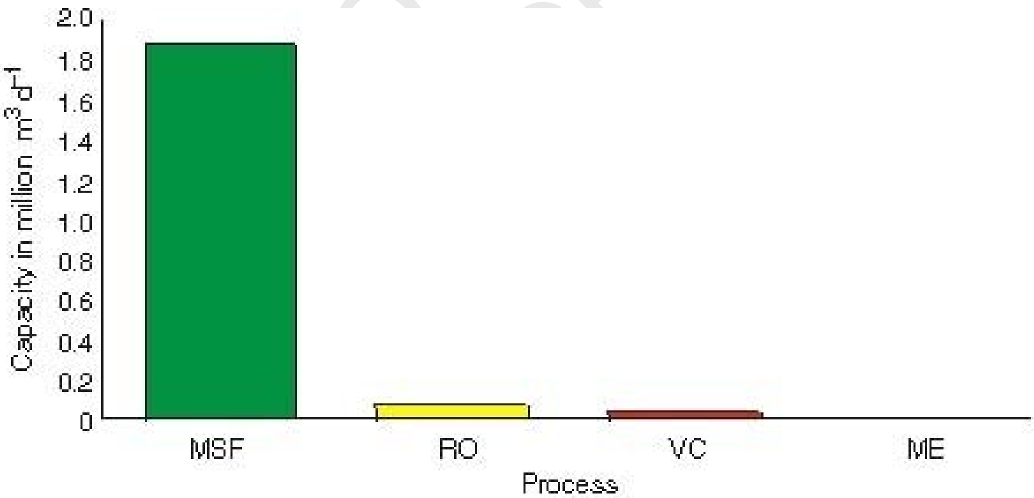

Figure 3. Installed seawater desalting capacity by various processes in the UAE.

The Water and Electricity Department (WED) of Abu Dhabi, which has been recently reorganized and renamed as Abu Dhabi Water and Electricity Authority (ADWEA), operates 30 large MSF desalination units with a total design capacity of about one million tons per day. These units, which were built by large engineering companies such as SIDEM, IHI and ITALIMPIANTI (IRITECNA), are grouped according to their unit capacity and location.

Figure 4 shows the pattern of water production during 1990-1993. It indicates that there was an average difference of about 15 per cent, between the summer and winter seasons.

Tables 1 and 2 present some features of these plants in the Emirate of Abu Dhabi where they operate in conjunction with thermal power plants. They are of cross tube type condenser design and the evaporator stages are arranged horizontally in two tiers that are stacked one above the other.

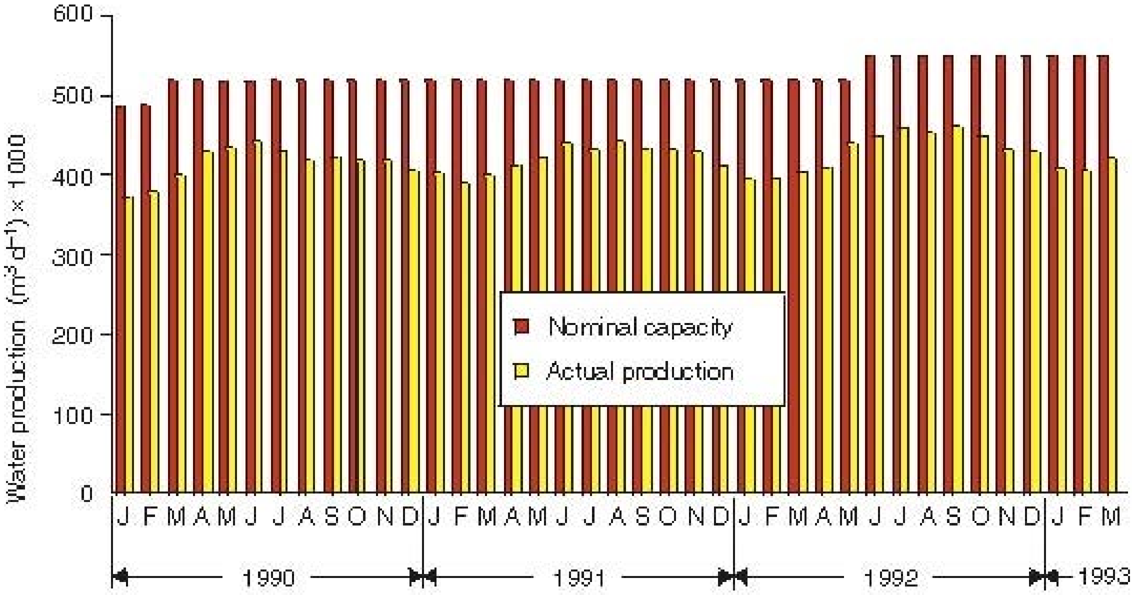

Figure 4. Water production pattern during 1990-1993.

Plant	Number of units	Design capacity of each unit (t d^{-1})	Starting period	Vendor
A	4	14 415	1976-1977	SIDEM
B	3	27 360	1979	SIDEM
C	6	18 160	1980-1981	IHI
D	4	27 360	1986	SIDEM
E	3	32 832	1987-1988	ITALIMPIANTI (IRITECNA)
F	4	32 832	1989-9194	SIDEM
G	6	57 600	1995-1996	ITALIMPIANTI (IRITECNA)
Total	30	933 564		

Table 1. Some desalination plants (groups of MSF units) supplying water to Abu Dhabi and Al Ain.

Group	Number of stages		Max temp (°C)	PR[a]	Tube material	
	Recovery	Rejection			Recovery	Rejection
A	13	3	90.0	6.0	Cu-Ni 30/Al Brass	Cu-Ni 30
B	13	3	102.0	6.0	Cu-Ni 30/Al Brass	Cu-Ni 30

Group	Number of stages		Max temp (°C)	PR[a]	Tube material	
	Recovery	Rejection			Recovery	Rejection
C	15	3	90.0	6.0	Cu-Ni 30/Al Brass	Cu-Ni 30
D	13	3	101.0	6.0	Cu-Ni 30/Al Brass	Cu-Ni 30
E	15	3	106.0	7.6	Cu-Ni 30/Cu-Ni 10	Cu-Ni 30
F	13	3	101.0	7.32	Cu-Ni 30/Cu-Ni 10	Cu-Ni 30

Table 2. Main design parameters of the plants.

3. Performance of the Plants

In addition to efficiency and economy, a very important performance criterion for desalination plants, is availability, i.e. the period during which it is fully operational. Most of the rest of this paper therefore focuses on the factors affecting plant availability.

Desalination plant operation without serious malfunctions is ideally desired, since continuous and reliable water supply is essential to the region. Much importance is therefore attached to high plant availability. However, despite careful choice of system configuration, state-of-the-art technology from appropriate suppliers and advice from expert consultants, plant malfunction events of varying severity have occurred in the past, significantly influencing plant availability. Table 3 and Figure 5 show the plant availability scenario in Abu Dhabi which should be understood in the light of reserve capacity and down-time for overhauls. Plant shutdown is mainly due to scheduled overhauls and unexpected malfunctions. Strictly speaking, plant down-time, which usually occurs during the cooler months, i.e. from October to April, should be separately viewed in availability assessment. During this period, plant availability is around 80 per cent. In the summer months, from May to September, overhaul operations are restricted and the mean availability is about 88 per cent. Thus, the average yearly availability over recent years has been about 84 per cent. During the summer months, when availability is high, if the production exceeds the demand plus storage capacity, the production rate of some units is deliberately reduced to avoid spill-over of the storage tanks. The reserve capacity is 3-5 MGD during summer and 2-4 MGD in winter. Examination of the various causes of plant shutdown is a prerequisite to all further discussions. Figure 6 summarizes this information, pointing out some issues for careful consideration as detailed below.

Group	Availability (%)
B	73
C	73
D	86
E	85
F	81
Overall (Jan 90-Mar 93)	80

Table 3. Average availability of desalination plants.

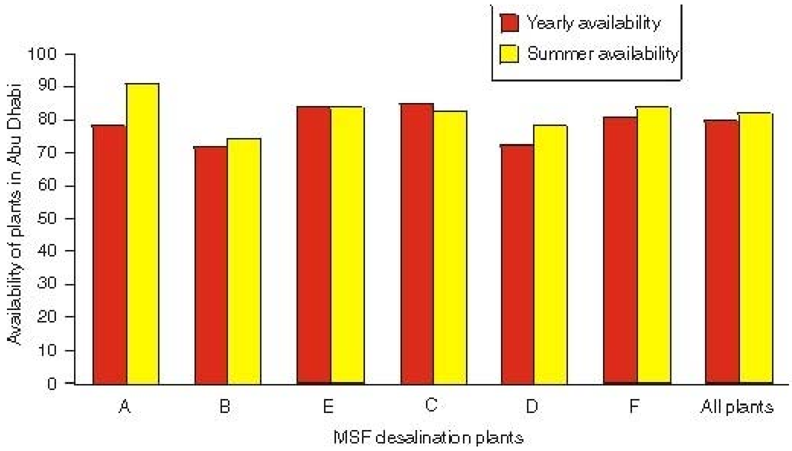

Figure 5. Plant availability during January 1990 to March 1993.

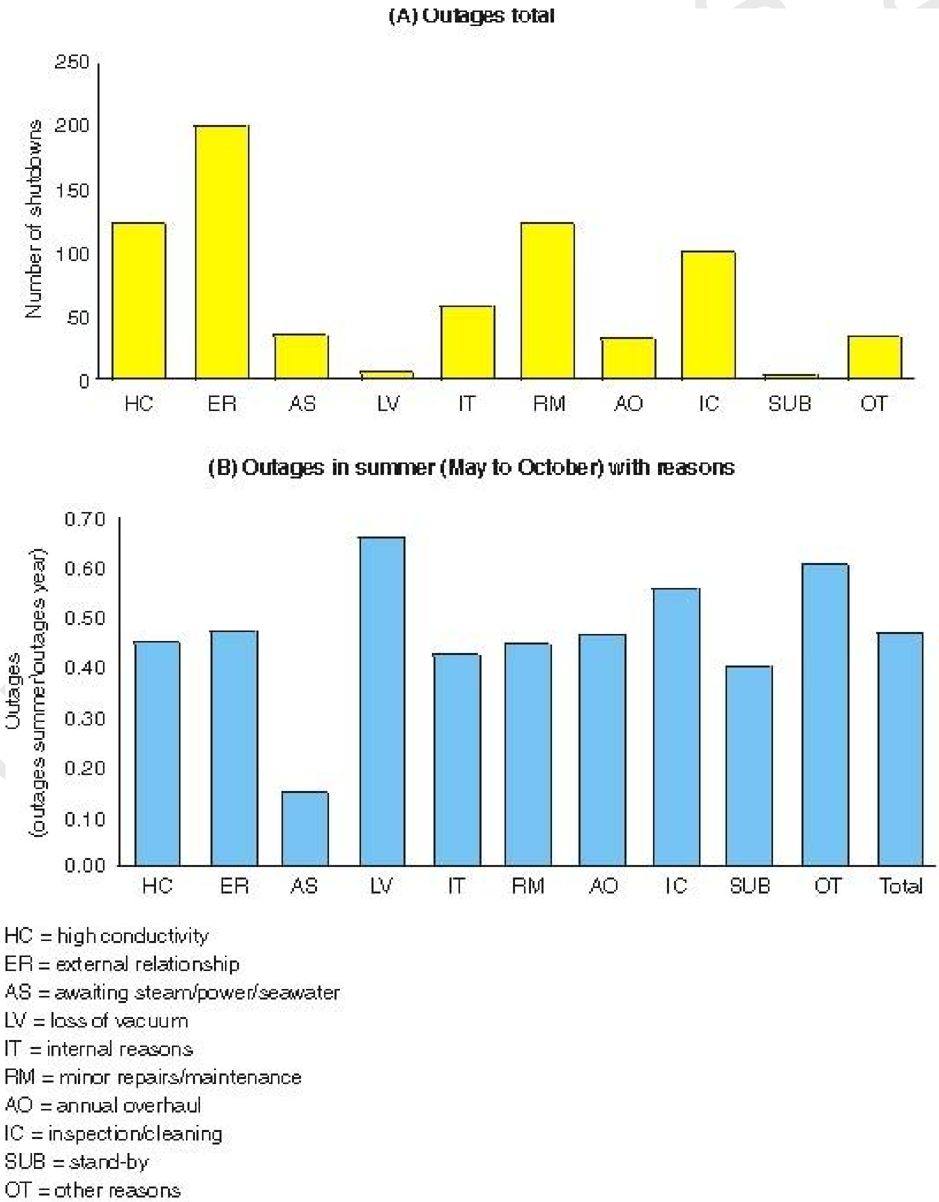

Figure 6. Outages with reasons.

3.1. Vapor Release, Demisters, Entrainment Alkaline Scale Formation and Operation at Low Seawater Temperature

3.1.1. Vapor Release Area

The vapor release area in a typical plant unit is in the range 600-1000 m^2. This is a design parameter that influences plant performance. In the newest plants, vapor release area is reduced by design and it is not possible to alter this factor in the existing plants.

3.1.2. Demisters

These large MSF plants are all equipped with demisters to prevent liquid droplets from being entrained in the vapor. Demister malfunction directly causes several operational problems such as

- Unacceptably high salinity of the product,
- Increased pressure loss in the demister leading to increased vapor temperature loss, and indirectly leads to several other problems of corrosion, heat transfer, etc.

Figure 7 shows the specific demister surface area related to distillate production in the various plants. Fine stage-wise progression of demister size, which is a feature of Group E, is shown in Figure 8. This results in optimal vapor velocities, and thereby leads to high separation efficiency.

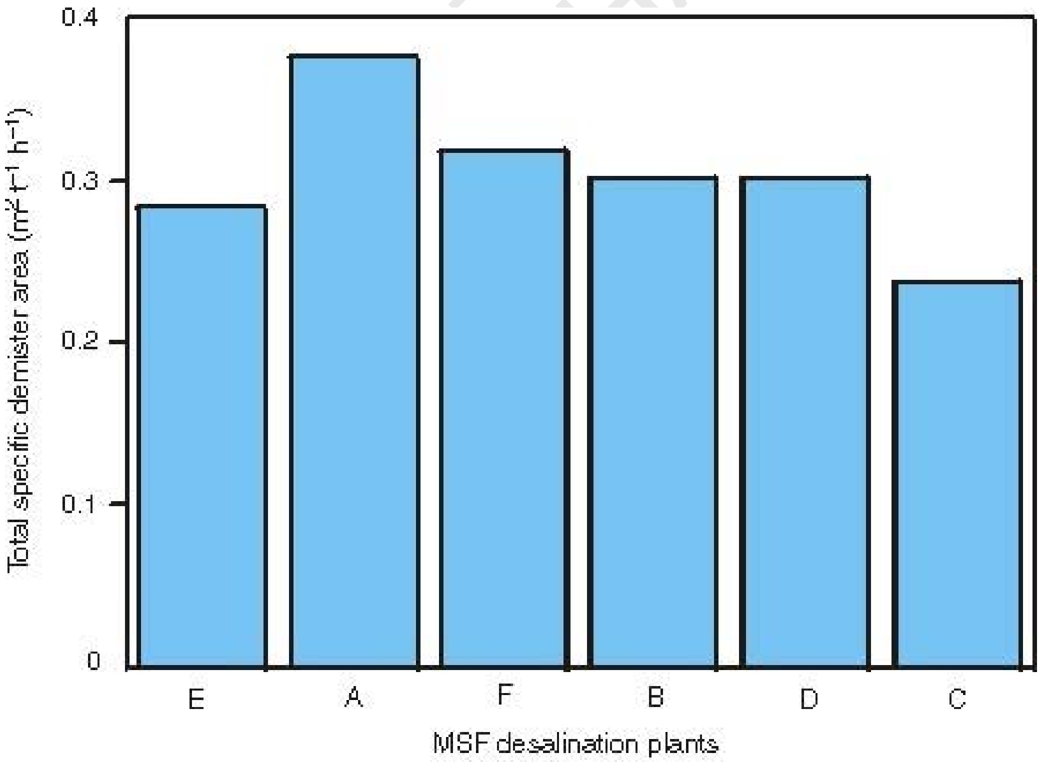

Figure 7. Specific demister surface area related to distillate production.

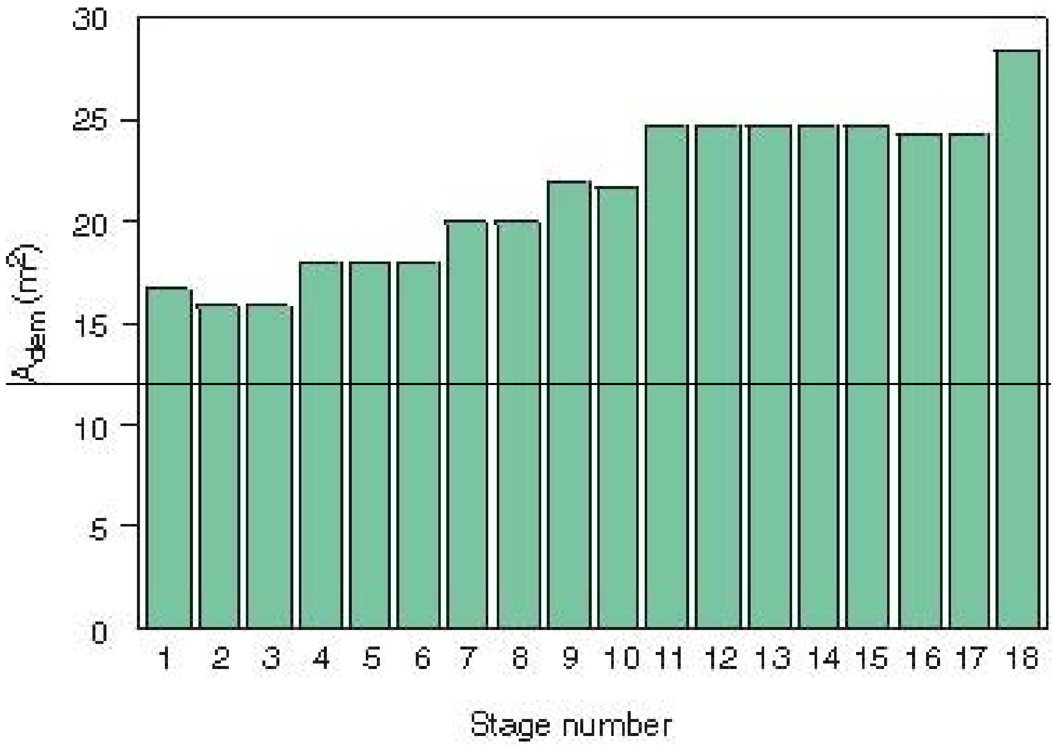

Figure 8. Demister sizes, Group E.

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