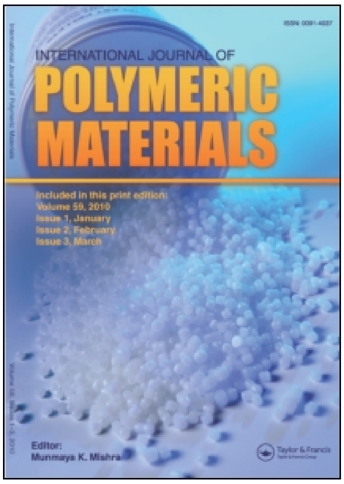

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Analysis of Theories in Computer Programmes for Estimation of Conveyor Belt Curing Time Part III: Temperature Distribution in Conveyor Belt

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A series of experiments were conducted for determination of temperature distribution in the conveyor belt and in the upper and lower surfaces of a roto-cure system. Contact times for various radiation zones are calculated and correlated with experimental data. The extent of heat of reaction and pre and post cures and their effect on curing time are discussed.

KEY WORDS Conveyor belt, curing time, roto-cure

INTRODUCTION

In part 2 of the present article a theoretical method, namely Sahand computer programme, for estimation of conveyor belt curing time and the effect of errors in the measurement of various parameters on the estimated curing time were discussed and analysed. It was concluded that the value of the computed curing time was sensitive mostly to errors and variations in the following parameters, listed in the order of decreasing influence:

(i) top and bottom press temperatures,
(ii) experimental curing temperature,
(iii) experimental curing time,
(iv) thermal diffusivity.

As an example, for a 10 mm thick conveyor belt, a 10% error in above parameters would result in, respectively, 65%, 35%, 5% and 3% error in the computed curing time. Thus errors due to parameters (iii) and (iv) are negligible, while that arising from (ii) can be minimised or prevented through careful measurement of rheometer temperature. The present contribution deals with the measurement of upper and lower surface temperatures and means of reducing the effect of temperature fluctuations on the curing time computed by the Sahand method.

EXPERIMENTAL PROCEDURES

Schematic diagram of a roto-cure system[1] used in this investigation is shown in Figure 1. The system consists of a preheating drum, a heating drum, a pressure roll and radiation heaters. The heating drum is divided into zones with angles as indicated.

TEMPERATURE MEASUREMENTS

Temperatures of layers in the conveyor belt and of top and bottom surfaces of the press were measured by means of Cu-Ni thermocouples placed inside the layers and moving with the belt covering the entire cure path. To avoid damage to the steel belt surface, thermocouple wires were led through narrow grooves carved on the outer surface of the bottom cover.

CONTACT TIME

From Figure 1 the length of time required for the belt to cover each zone was calculated and the results expressed in terms of time fractions (ratio of zone contact time to total contact or set time). These results are utilised in the analysis of practical data.

RESULTS AND DISCUSSION

Results of temperature measurements and time fraction calculations are shown in Tables I and II and illustrated in Figures 2 to 12. Good conformity of contact times

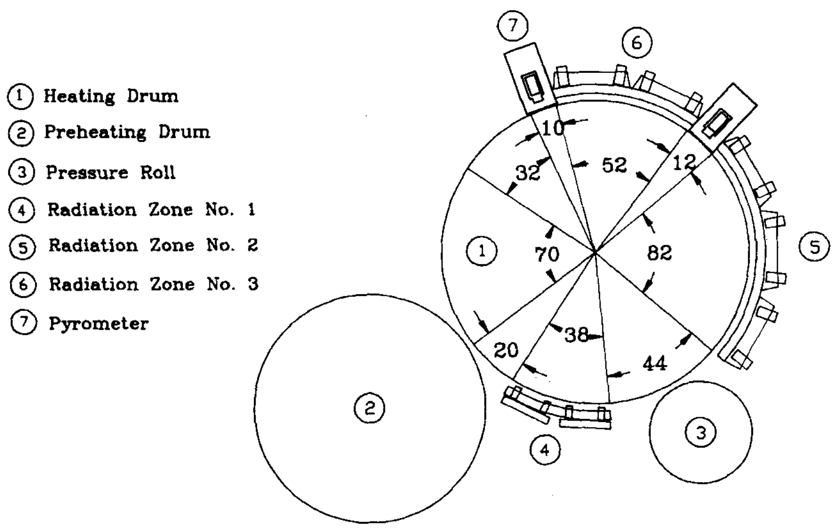

FIGURE 1 Schematic diagram of roto-cure system.

TABLE I

Temperature measurements

Experiment No.	location of thermocouple tip[a]	Temperature of heating drum (°C)[b]	Temperature of preheating drum (°C)	Percent of electric current in radiation zones			Set time[c] (min)
				Zone 1	Zone 2	Zone 3	
1-1	A(15)[d]	163.0	156.0	50	50	40	20.0
1-2	A(15)	163.0	156.0	50	50	40	20.0
1-3	A(15)	163.0	156.0	55	55	45	20.0
2-1	B(15)	162.0	156.0	50	50	40	19.0
2-2	C(15)	162.0	156.0	50	50	40	19.0
2-3	A(15)	162.0	156.0	50	50	40	19.0
3-1	A(15)	162.0	155.0	44	44	34	19.0
3-2	A(15)	162.0	155.0	47	47	37	19.0
3-3	A(15)	162.0	155.0	50	50	40	19.0
3-4	A(15)	162.0	155.0	53	53	43	19.0
3-5	A(15)	162.0	155.0	56	56	46	19.0
3-6	A(15)	162.0	155.0	59	59	49	19.0
4	A(15)	162.5	156.5	50	50	40	18.5
5-1	D(15)	162.5	157.0	53	53	43	19.0
5-2	D(15)	162.5	157.0	56	56	46	19.0
5-3	D(15)	162.5	157.0	59	59	49	19.0
5-4	D(15)	162.5	157.0	62	62	52	19.0
6-1	B(35)	162.0	157.0	50	50	40	19.0
6-2	B(80)	162.0	157.0	50	50	40	19.0
6-3	E(10)	162.0	157.0	50	50	40	19.0
6-4	F(10)	162.0	157.0	50	50	40	19.0
7-1	B(20)	154.0	147.5	0	0	0	13.0
7-2	B(40)	154.0	147.5	0	0	0	13.0
7-3	B(60)	154.0	147.5	0	0	0	13.0

[a] Location of thermocouple tip:
A = between steel belt and conveyor belt,
B = between heating drum and conveyor belt,
C = between first and second layers of carcass,
D = between top cover and carcass,
E = between heating drum and stripper,
F = between steel belt and stripper.

[b] Temperature obtained from thermodynamic table for saturated steam.

[c] Total conveyor belt - heating drum contact time.

[d] Figures in parentheses indicate distance between thermocouple tip and drum edge, in cm.

for the three radiation zones shown on the temperature profiles with experimental data confirms the validity of the method used for their calculation. Figure 2 relates to the measurement of temperature of steel belt in which percent current in radiation zones for Experiment no. 1-3 is seen to increase, and the closeness of the results for Experiment nos. 1-1 and 1-2 indicates the excellent reproducibility which can be expected in the present investigation.

Figure 3 shows temperature profiles for various parts of the belt and for the post cure (Experiment no. 2) using the temperature of the parts and a value of 1.9 for

TABLE II

Time fractions

Zone	Zone angle (degree)	Time fraction
Start of cure to radiation zone 1 interval	20	0.069
Radiation zone 1	38	0.132
Radiation zone 1 to radiation zone 2 interval	44	0.152
radiation zone 2	82	0.283
Radiation zone 2 to radiation zone 3 interval	12	0.041
Radiation zone 3	52	0.179
Radiation zone 3 to end of cure interval	42	0.145

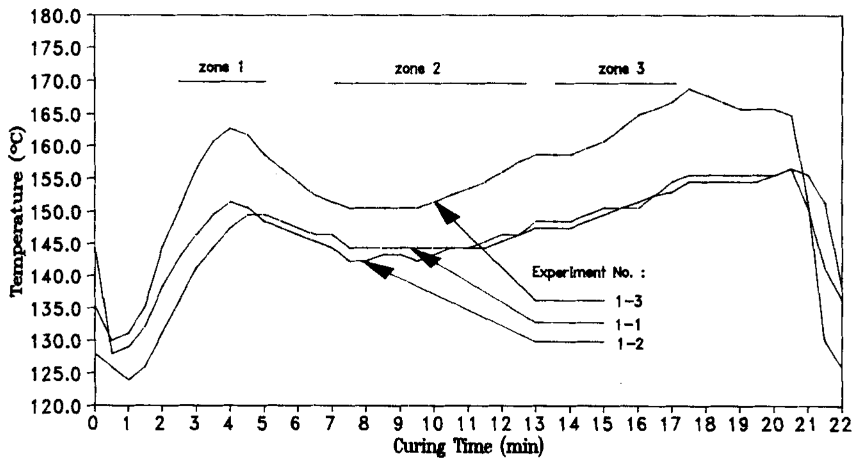

FIGURE 2 Temperature profile in conveyor belt—Experiment no. 1.

the temperature coefficient of vulcanisation and taking the experimental temperature for 90% cure equal to 156°C, the amount of main and post cures corresponding to Experiment nos. 2-1 to 2-3 were estimated and are shown in Figures 4 to 6. It can be seen that appreciable amounts of post cure occur in all three cases and that this therefore should be taken into consideration in the computation of conveyor

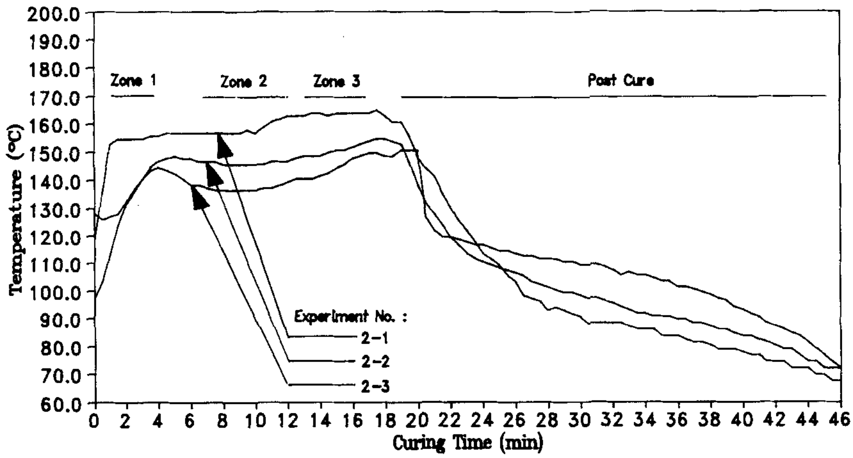

FIGURE 3 Temperature profile in conveyor belt—Experiment no. 2.

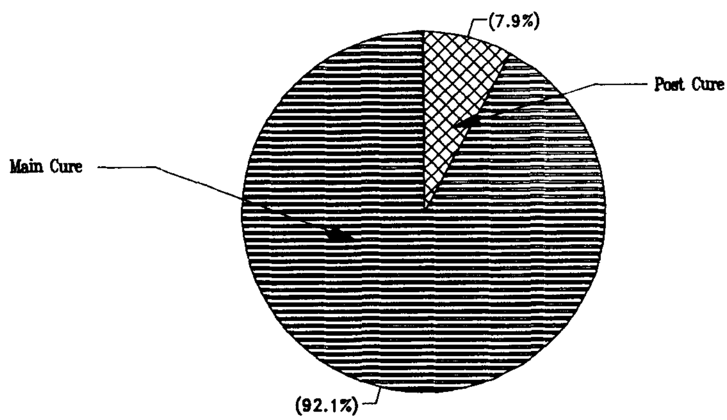

FIGURE 4 Comparison of main cure and post cure (Experiment no. 2-1).

belt curing time. The highest amount of post cure takes place in the outer surface of the bottom cover and the lowest in the uppermost surface of the top cover.

Figure 7 illustrates the results of six experiments to measure the temperature of the steel belt surface (Experiment no. 3). Except for Experiment no. 3-5, percentage of currents indicates an almost linear relationship between steel belt surface temperature and percent current in radiation zones, with little error within the set limits of 40% to 60% current.

Steel belt surface temperature profile is again shown in Figure 8 (Experiment no. 4), together with preheating temperature, from which preheating cure was estimated as explained before and is compared with main cure and post cure in Figure 9. It is evident that whereas the post cure remains significant, the extent of preheating cure is small (2.2%) and that its omission would not be expected to cause much error in the computed curing time. It should be noted that the above degree of preheating cure is the highest in the conveyor belt and is that of the

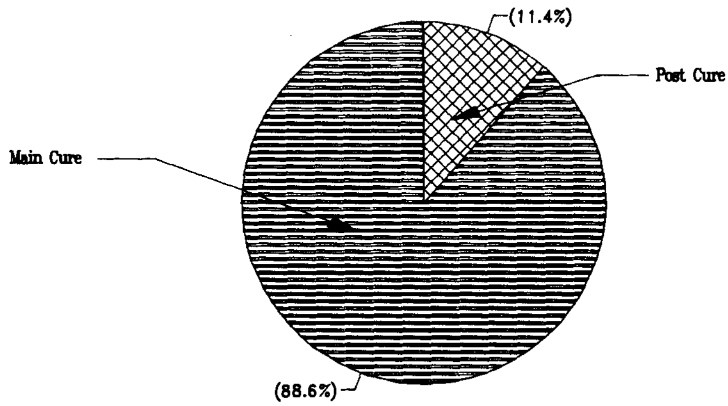

FIGURE 5 Comparison of main cure and post cure (Experiment no. 2-2).

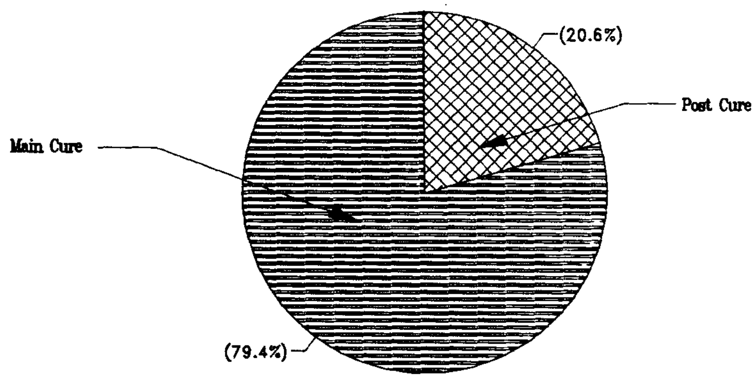

FIGURE 6 Comparison of main cure and post cure (Experiment no. 2-3).

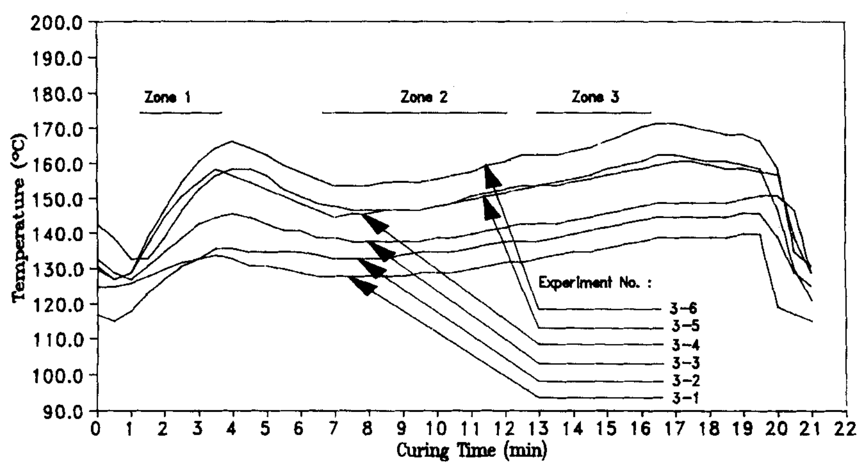

FIGURE 7 Temperature profile in conveyor belt—Experiment no. 3.

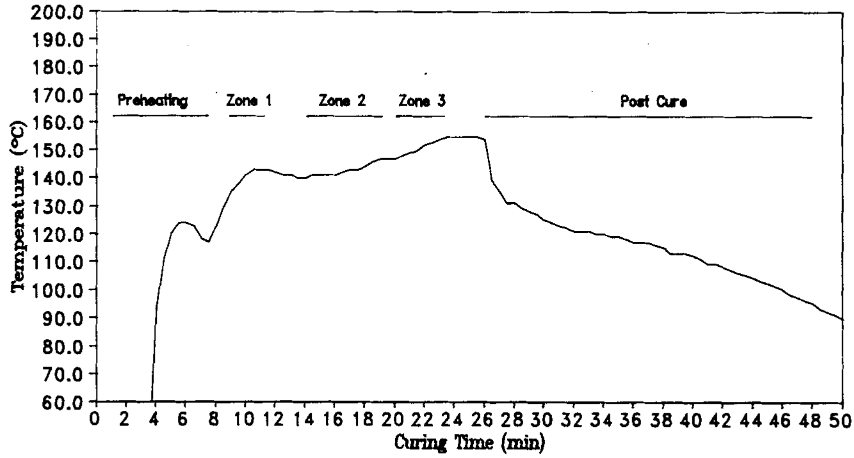

FIGURE 8 Temperature profile in conveyor belt—Experiment no. 4.

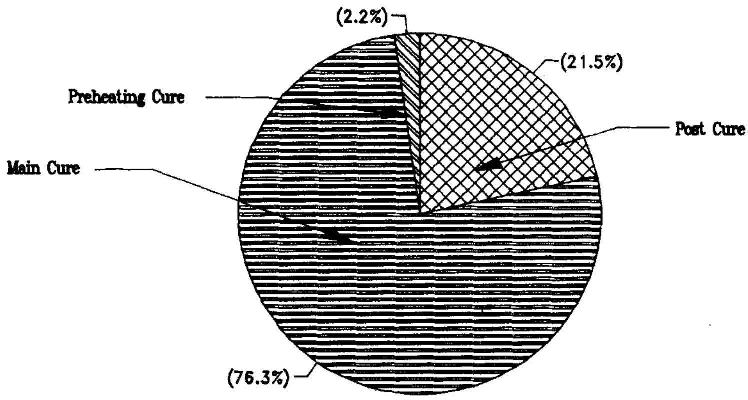

FIGURE 9 Comparison of main, preheating and post cures (Experiment no. 4).

outermost surface of the bottom cover due to its direct contact with the steel belt surface.

Results of Experiment no. 5 concerning the top cover and carcass are seen in Figure 10 showing the near linear effect of variations in the percent current of radiation zones. Temperature profiles shown in Figure 11 relate to the measurement of heat of reaction which was accomplished using a stripper (a vulcanised rubber belt used in the curing of narrow conveyor belts to prevent damage to the steel belt). Top cover surface temperature was measured at points 35 to 80 cm from drum edge and by placing the thermocouple tip on the stripper (Experiment nos. 6-1 to 6-3). Coincidence and shape of the curves reveals two facts. First, no appreciable temperature variation exists across the belt, and second, the amount of heat of reaction is insignificant.

A sudden increase in temperature in the middle parts of radiation zone 2 is observed for most of the profiles. This cannot be attributed to the effect of heat of reaction as evident from comparison of curves 6-1 and 6-3 (Figure 11). To

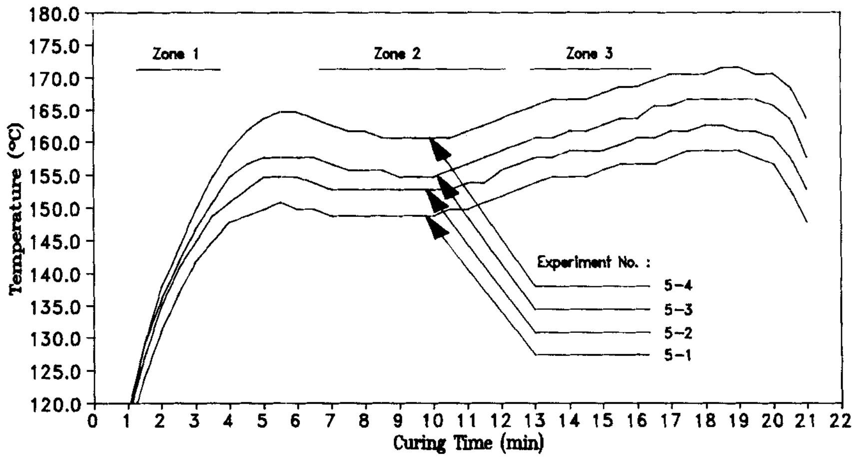

FIGURE 10 Temperature profile in conveyor belt—Experiment no. 5.

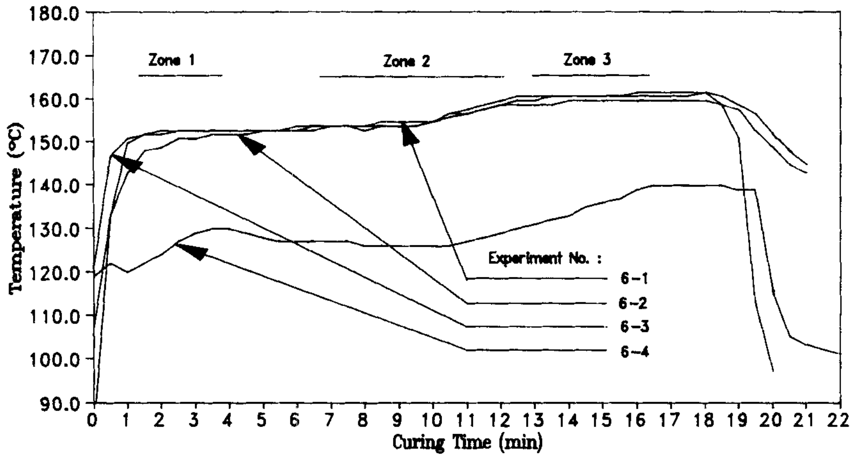

FIGURE 11 Temperature profile in conveyor belt—Experiment no. 6.

examine the effect of radiation heater, the previous set of experiments were repeated with heaters disconnected. The results, as reported in Figure 12 (Experiment nos. 7-1 to 7-3), however, dismiss this suggestion. The only possible explanation for the increase in temperature may lie in the internal structure of the heating drum. Arrival of fresh steam in the above zone can increase the temperature of the drum surface at that point.

Considering the above points, the present computer programme is sufficiently accurate and error free for the estimation of conveyor belt curing time in a batch curing system. For a continuous curing system, however, use of average values of experimentally determined upper and lower heat source temperatures is essential. In the absence of such information, acceptable results may be obtained through assuming linear relationships between set percent current and steel belt tempera-

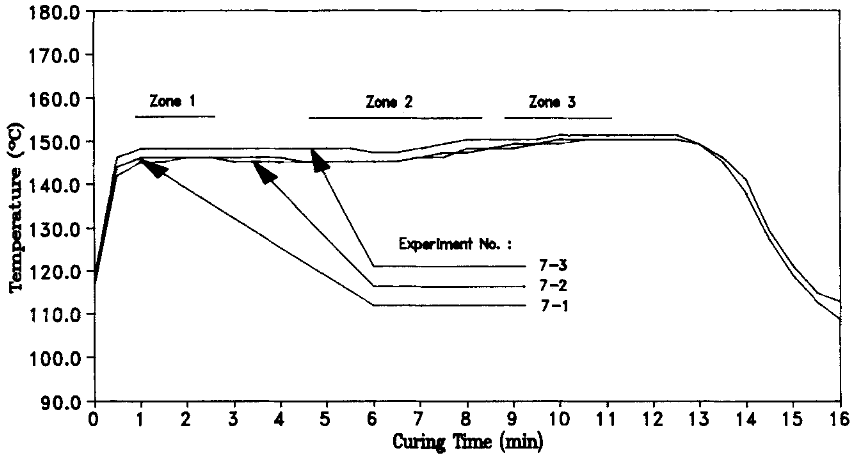

FIGURE 12 Temperature profile in conveyor belt—Experiment no. 7.

ture, and by taking the upper temperature equal to 2 to 3 degrees less than that obtained from thermodynamic tables for saturated steam.

Work on the two dimensional (length and thickness) heat transfer analysis of conveyor belt is currently in progress for further evaluation of the Sahand computer method.

CONCLUSION

Based on the observation made, the following inferences can be drawn:

1. The magnitudes of heat of reaction and preheating cure are negligible.
2. The extent of post cure is significant and should be taken into consideration.
3. Temperature variation across the belt is insignificant.
4. For a continuous curing system, in the event of uncertainty, upper and lower temperatures may be estimated, respectively, from thermodynamic tables for saturated steam after slight adjustment, and from percent current-temperature linear relationships.

Acknowledgment

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Reference

1. Berstorff, H., Technical Documents AUMA 15 S × 1500, Machine No. 90-1-A0, 6733-47/84.