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PITFALLS IN THE USE OF NOISE SUPPRESSION IN ULTRASONIC FLAW DETECTION

by

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Traquenards dans l'emploi de la suppression des bruits pour la détection ultrasonique des défauts

par

R. I. Coote et J. H. C. Long

Résumé

Les effets du contrôle par suppression de bruits sur deux instruments d'essais ultrasoniques, un Krautkramer USIP 11 et un Branson 303, ont été documentés en vérifiant la linéarité verticale des amplificateurs, la précision des contrôles de gains calibrés et l'effet en résultant sur les signaux de défauts.

Bien qu'un signal de calibrage puisse être maintenu à un niveau constant lorsqu'on a recours à la suppression des bruits on a constaté que des signaux de défaut significatifs on été réduits en amplitude ou éliminés complètement.

Il est recommandé que l'emploi de la suppression des bruits soit évité à moins qu'un défaut supplémentaire de calibrage soit employé pour définir le niveau de signal minimal présentant un intérêt.

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ABSTRACT

The effects of the noise suppression control on two ultrasonic test instruments, a Krautkramer USIP 11 and a Branson 303 have been documented by checking the amplifiers' vertical linearity, the accuracy of the calibrated gain controls, and the resulting effect on defect signals.

Although a calibration signal can be maintained at a constant level when noise suppression is used, it is found that significant defect signals are reduced in amplitude or eliminated completely.

It is recommended that the use of noise suppression be avoided unless an additional calibration defect is used to define the minimum signal level of interest.

Chalk River Nuclear Laboratories
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PITFALLS IN THE USE OF NOISE SUPPRESSION IN ULTRASONIC FLAW DETECTION

1. INTRODUCTION

Most ultrasonic instruments used for flaw detection have a noise suppression control (also called a reject or threshold control) which can be used to suppress small echoes displayed on the instrument screen. Its use is popular to "clean-up" the display by eliminating unwanted signals; however the full implications of its use are not generally recognized by operators of the equipment. Manufacturers of ultrasonic equipment do not adequately describe the effects of noise suppression, and its use is seldom mentioned in inspection codes and practices. Section 4.2 of B.S.* 3923: Part 1: 1968 is one of the few standards that mentions suppression: "The use of suppression should be avoided whenever possible, but where its use is considered necessary, its effect over the full range shall be known".

This report documents the effects of the noise suppression control on two instruments, a Branson 303 and a Krautkramer USIP 11. The USIP 11 instrument has five graduated positions and a positive off setting on the control. The Branson instrument has no graduation marks or a positive off position. Positions of 1/3, 2/3 and 3/3 of the maximum setting were used for these tests. The suppression control on both these instruments makes the amplifier non-linear, amplifying small signals less than large ones. The effect has been demonstrated in three different ways:

1. The effect of suppression on vertical linearity

*British Standard.

2. The effect of suppression on the calibrated gain control.
3. The effect of suppression on detection and evaluation of defect signals.

The first two items are performance requirements frequently mentioned in ASME* and CGSB specifications, while the third expresses these performance results in terms of defects.

2. VERTICAL LINEARITY

The CGSB recommended practices for Ultrasonic Inspection of Structural Welds, 48-GP-6a, requires that the deviation from vertical linearity be less than 5 percent over the range of 10 to 75% of the upper vertical limit. The immersion method outlined in ASTM† E317-68 was followed to check the vertical linearity of the two instruments. With the suppression control turned off, the instrument sensitivity was set by obtaining a signal amplitude of 5 mm from the flat bottomed hole of ASTM Reference Block No. 5-0075. The vertical linearity was then checked by measuring the amplitudes of the multiple backwall signals obtained from a parallel-faced calibration block 5 mm thick, as outlined in section 6.2 of ASTM 317-68. The complete procedure, including setting of the initial sensitivity, was then repeated using increased amounts of noise suppression.

The results for the Branson and Krautkramer instruments are shown in the form recommended by ASTM in Figures 1 and 2. With the largest amount of suppression, neither instrument is linear over any part of the screen.

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*American Society of Mechanical Engineering
†American Society for Testing and Materials

3. CALIBRATED GAIN (OR ATTENUATION) CONTROL

Paragraph T-511 b in section V of the ASME Code states that when specifically required, the calibrated attenuator of an instrument should be accurate over its range to ±2 dB or ±20 percent. A signal with 100% amplitude should be reduced to 79%, 63% and 50% for a decrease in gain of 2 dB, 4 dB and 6 dB respectively. The results shown in Tables 1 and 2 were obtained by setting the interface signal of a normal beam incident on an immersed pressure tube to 100% using no suppression and then decreasing the instrument gain by 2, 4 and 6 dB, and measuring the resulting signal amplitudes.

This procedure was then repeated with increasing amounts of suppression.

4. DEFECT DETECTION AND EVALUATION

Although evaluation of the vertical linearity and the accuracy of the calibrated gain control are two methods of relating the effect of suppression to the CGSB and ASME requirements, none of these results clearly illustrate the effect of suppression on defect detection and evaluation which is the essential purpose of ultrasonic inspection.

Artificial defects made by electro-discharge machining radial notches .063, .127 and .254 mm deep, parallel to the axis of a pressure tube sample, were used as examples of flaws. It is really the signal amplitudes from these different flaws that are of interest. The signals could equally well represent defects in any material such as a plate, a weld or a casting.

The signal amplitudes from the notches were measured with increasing amounts of suppression while maintaining the notch chosen as the calibration level at a fixed amplitude by increasing the instrument gain. In Figure 3a for example, the signal from the .254 mm deep notch was chosen as the calibration level, and by adjusting the gain, it was maintained at 100% of screen as the amount of suppression on the Branson 303 was increased. Thus, even though the apparent calibration sensitivity remains the same as suppression is increased, the signals from the smaller defects are drastically reduced and finally eliminated completely as the amount of suppression is increased to 2/3 of the maximum.

The same effect of suppression in eliminating signals smaller than the calibration signal can be seen in Figure 3b where the .127 mm notch is used as a 100% calibration level and in Figure 3c where the .254 mm notch is used as a 60% calibration signal. The equivalent results for the USIP 11 instrument are shown in Figure 4. Although qualitatively the results for the USIP 11 are similar, the magnitude of the suppression effect is not as large as for the Branson 303. This confirms the results for linearity and gain calibration which indicated the larger effect of the suppression control on the Branson 303.

5. DISCUSSION

The results clearly indicate that the suppression control on the Branson 303 has a much larger effect on linearity, gain control accuracy and small signal suppression than the control of the Krautkramer USIP 11.

The noise suppression control is simply intended to suppress noise signals not related to defects. Unfortunately, the instrumentation cannot distinguish a true noise signal from a real defect signal, and it therefore indiscriminately suppresses all small signals, and for large settings of suppression relatively large signals as well.

The results with the artificial defects indicate it is not really possible, by using the suppression control, to effectively eliminate small signals which may be noise, without also reducing the amplitude of real defect signals. If only a very small amount of suppression is used to avoid suppressing defect signals, then noise will not be effectively suppressed.

Figures 1 and 2 summarize the effect of suppression on vertical linearity. Ideally the ratio of any two signal amplitudes should be constant over the full screen height, so that the linearity curve would be a vertical line. Even at the lowest suppression settings evaluated, neither instrument would satisfy the CGSB requirement for less than 5% deviation from linearity.

Similarly the accuracy of the calibrated gain control would not meet the ASME requirement even for a suppression setting of only 2 on the USIP 11 or 1/3 of maximum on the Branson 303. Although both instruments will satisfy the CGSB and ASME requirements for linearity and gain control accuracy with the suppression off, it is surely not the intention of either CGSB or ASME to require evaluation of the performance with no suppression, and then allow inspection using suppression which invalidates the previous performance evaluation.

The essential effect of suppression however is in defect detection and evaluation. Most ultrasonic inspection specifications contain a requirement that inspected items will be rejected if they contain a defect which produces an ultrasonic signal larger than the calibration level. If that was the only requirement, then any amount of noise suppression would be acceptable provided the calibration signal was maintained at the given level. However, in addition to the simple accept-reject criterion, most specifications require that signals smaller than the calibration level be evaluated. For example, paragraph NB 5330 in Section III of the ASME Code requires that signals above 20% of the calibration level be investigated to determine the location and identity of the reflector. As shown in Figures 3 and 4 a signal which is truly above 20% of the calibration level (with no suppression) can be reduced below the 20% level with only a small amount of suppression, or eliminated completely with more suppression. ASME requires investigation of small signals because it is generally recognized that a serious defect, because of its shape or orientation may well produce a signal which is only a fraction of the arbitrary calibration level.

The AECL specification TS-XX-31110-5 for pressure tube inspection requires that indications above 20% of the calibration level be investigated to obtain the maximum signal amplitude and prohibits the use of suppression. In this case the inspection is mechanized with the signals recorded on a chart recorder and an interlock set to stop the inspection for investigation of signals >20%. If only 1/3 of the full suppression on the Branson 303 was used even a true 45% signal would not set off the alarm, and a true 20% signal would not show at all on the chart recorder.

6. RECOMMENDATIONS

The noise which the suppression control is intended to eliminate may arise from a number of causes such as electrical interference from other equipment, scattered beams from a rough surface or coarse grain structure, or stray beams in an immersion tank. The presence of noise can be annoying and ideally its source should be eliminated. If this is not possible, it should be realized that only defect signals which are larger than the noise level can be identified. There are two alternatives:

1. Use no suppression and simply ignore signals below a specified noise level. This is the preferred method particularly for mechanized devices with chart recording of data since even the presence of noise provides an indication that the equipment is operating, and the true relationship between signal amplitudes is preserved.

2. If two calibration defects can be provided, one defining the simple acceptance level and the other defining the level requiring investigation, then noise suppression could be allowed as long as the signals from these defects are displayed above a minimum amplitude.

The non-linear amplification of signals by the instruments used for the above tests is the most common method of noise suppression. One instrument however, a Krautkramer KS 3000, uses a completely different method, and linearly amplifies only signals above a threshold level, while completely eliminating signals below the threshold. The results of similar tests on this type of instrument would likely lead to different recommendations.

TABLE 1: Effect of Suppression on Calibrated Gain Control Accuracy of USIP 11

Attenuation (dB)	Amplitude (%)			
	0	2	4	6
Suppression				
0	100	80	60	50
1	100	75	55	40
2	100	70	45	20
3	100	65	35	15
4	100	62	25	7
5	100	62	25	7
Theoretical	100	79	63	50

TABLE 2: Effect of Suppression on Calibrated Gain Control Accuracy of Branson 303

Attenuation (dB)	Amplitude (%)			
	0	2	4	6
Suppression				
0	100	85	68	50
1/3	100	74	47	20
2/3	100	64	25	0
Full	100	60	10	0
Theoretical	100	79	63	50

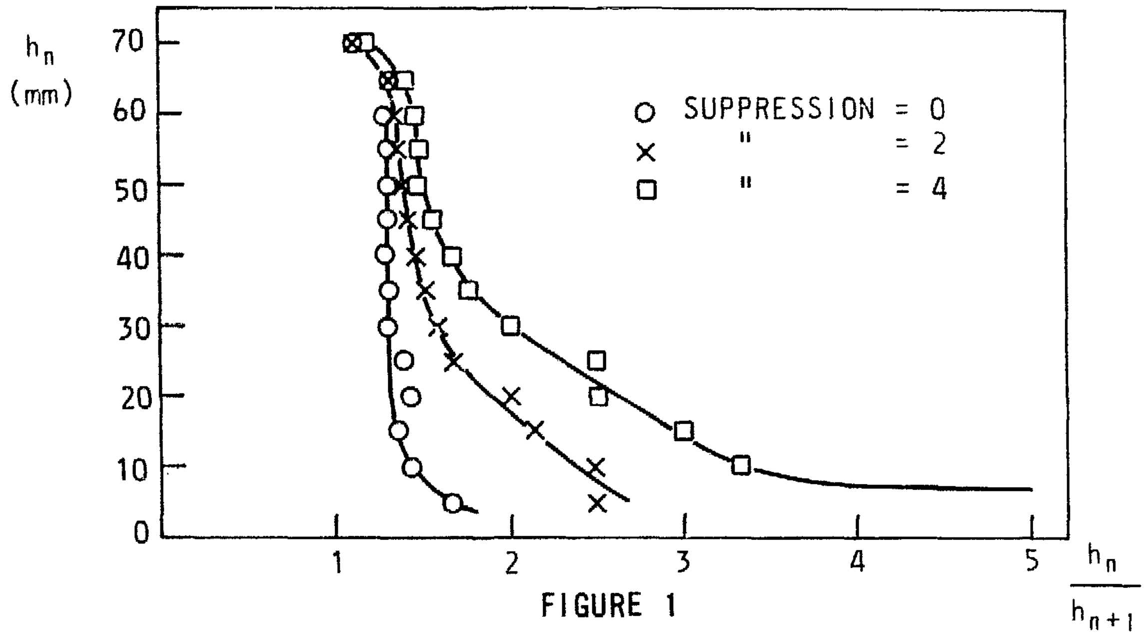


FIGURE 1

VERTICAL LINEARITY OF KRAUTKRAMER USIPII

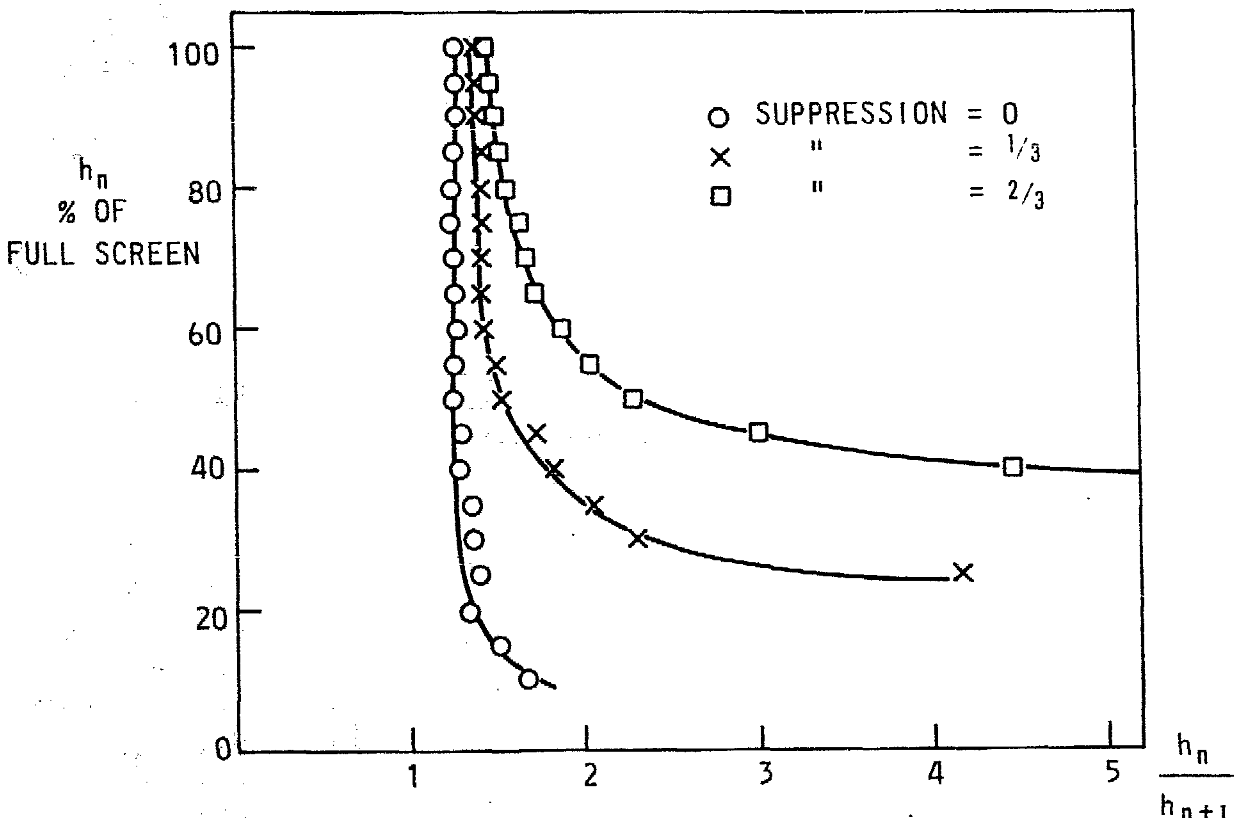
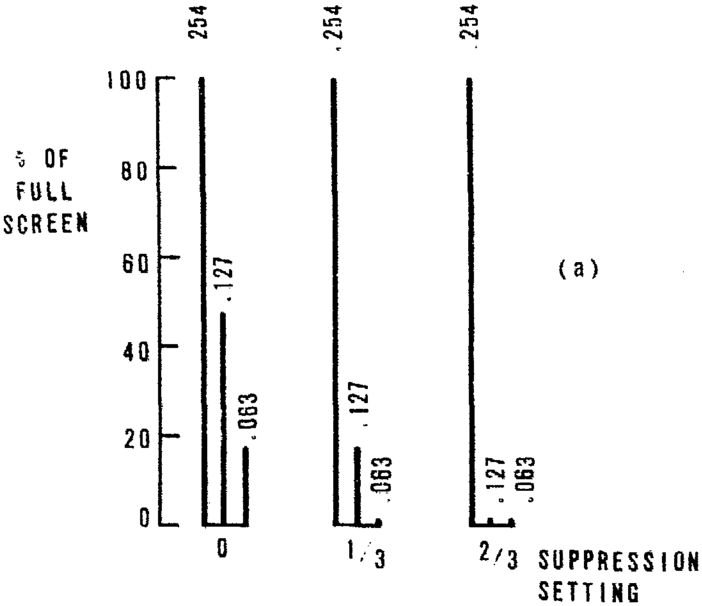


FIGURE 2

VERTICAL LINEARITY OF BRANSON 303



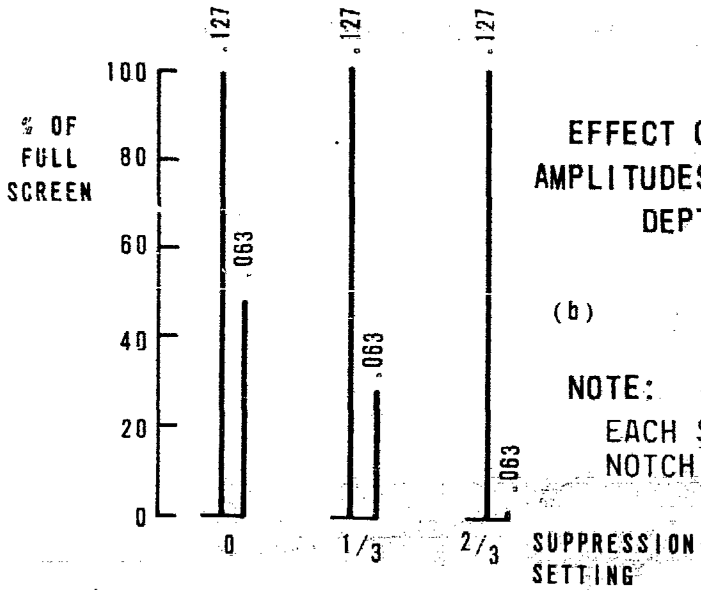
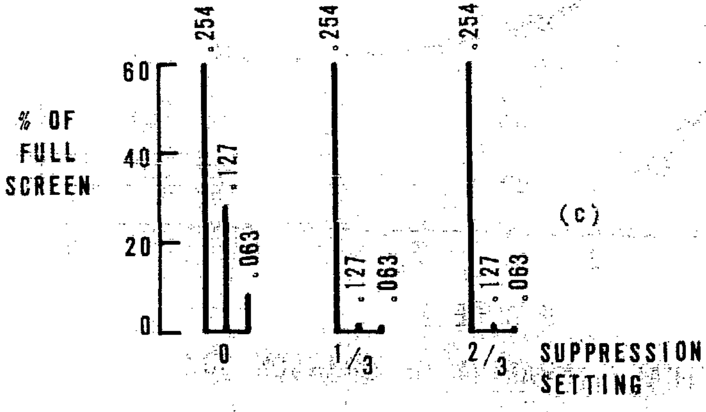
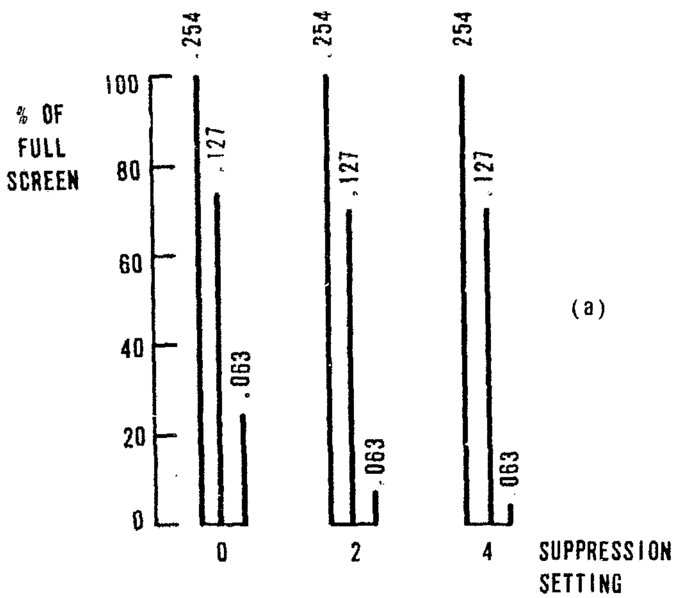


FIGURE 3

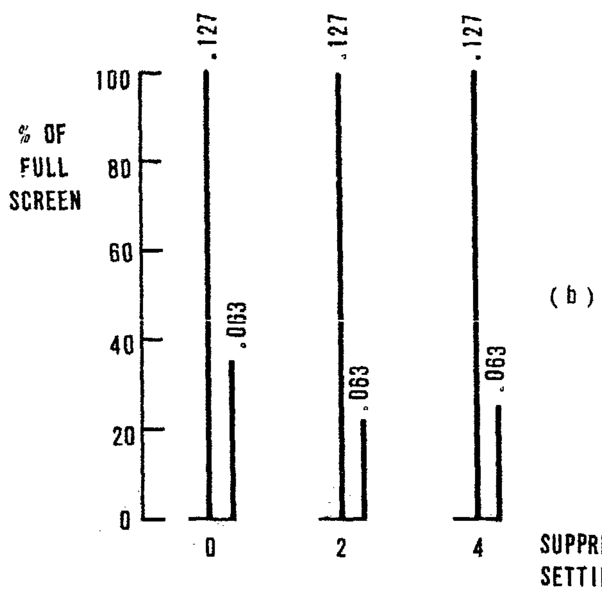
EFFECT OF SUPPRESSION ON SIGNAL AMPLITUDES FROM NOTCHES OF VARYING DEPTHS WITH BRANSON 303

NOTE:
EACH SIGNAL IS LABELLED WITH THE NOTCH DEPTH IN mm





(a)



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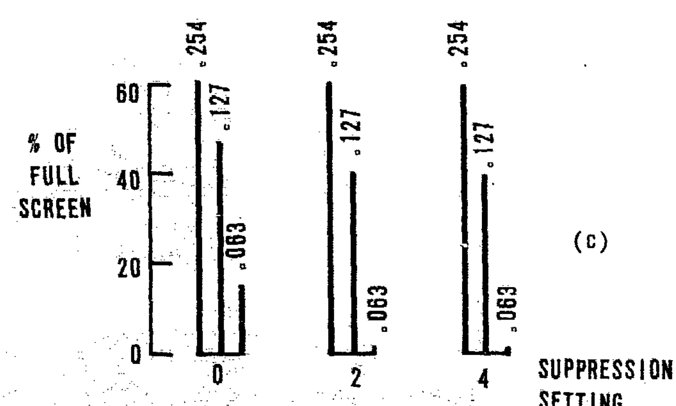


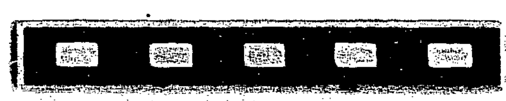
(c)

FIGURE 4

EFFECT OF SUPPRESSION ON SIGNAL AMPLITUDES FROM NOTCHES OF VARYING DEPTHS WITH KRAUTKRAMER USIPII

NOTE:

EACH SIGNAL IS LABELLED WITH THE NOTCH DEPTH IN mm



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