PV Eng
Pressure Vessel Engineering

Joint efficiency is a factor required in all head and shell calculations that accounts for how closely a finished weld joint approximates the quality of the seamless parent material. Without further inspection it is assumed the welded joint is weaker than the material around it due to potential defects such as porosity, slag inclusions, and others. Shell thickness and therefore weld quantity is increased to account for this reduction in strength. Code welders following a qualified weld procedure are tested to weld a finished joint that maintains 100% of the parent material strength, but without further testing the allowed strength of a production joint is reduced to 70%.

For some design conditions, such as lethal service, the Code requires the designer to specify full radiography. However, when not required, the designer can specify optional radiographic examination to increase joint efficiency and reduce the required thickness of shells and heads. The designer weighs the material and welding costs against inspection costs to determine which course is best suited for the application.

The figures below show the ASME VIII-1 joint efficiency values based on Type 1 joints (butt joints fully welded from both sides or equivalent) and degree of radiographic examination. The information is generated using the radiography logic diagrams and samples from Part 7 of PTB-4-2013 ASME Section VIII – Division 1 Example Problem Manual – the PTB-4 ‘E7.1’ through ‘E7.4’ example numbers are indicated where applicable.

No Radiography

ASME PTB-4 Ref. No.: None

———— E = 0.70

– – – – – – – E = 0.85

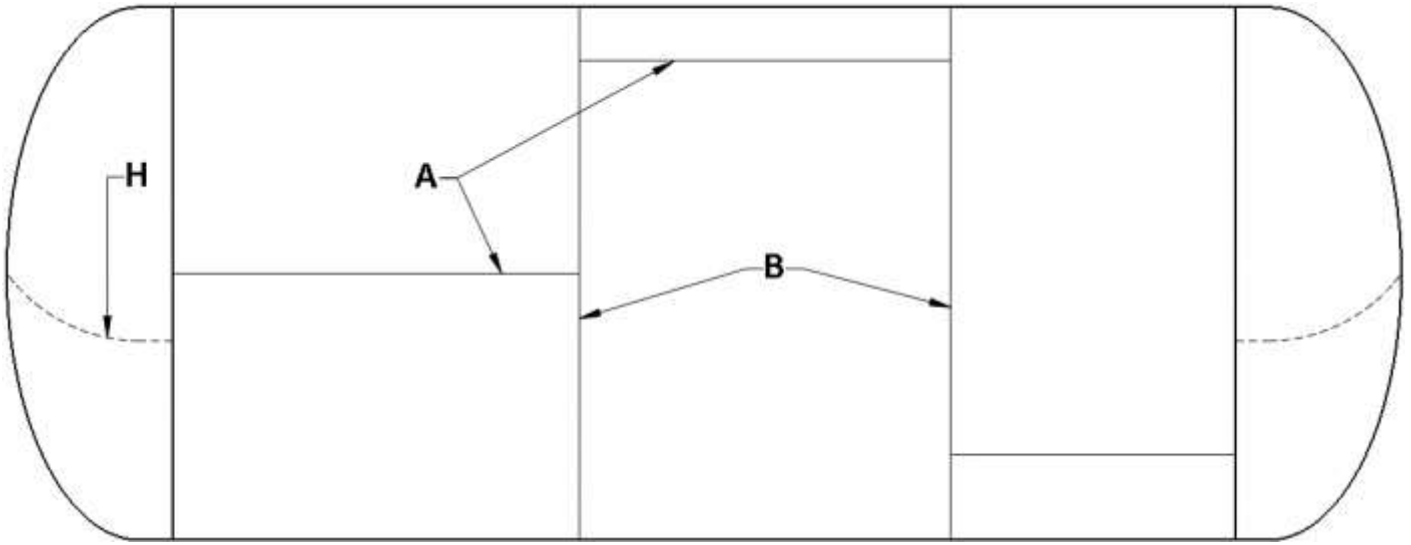


***Figure 1**. Sample vessel illustrating joint locations and efficiency for No Radiography*

Visual examination with no radiography is the simplest inspection option. All shell joints (A and B) have an efficiency of 0.70.

The seamless head efficiency is reduced from 1.00 to 0.85 since the shell circumferential seam it intersects is not inspected per code rule UW-12(d). This is shown as the “imaginary” seam H in the figure.

RT-4 Option 1

ASME PTB-4 Ref. No.: None

E = 0.85

E = 0.70

E = 0.85

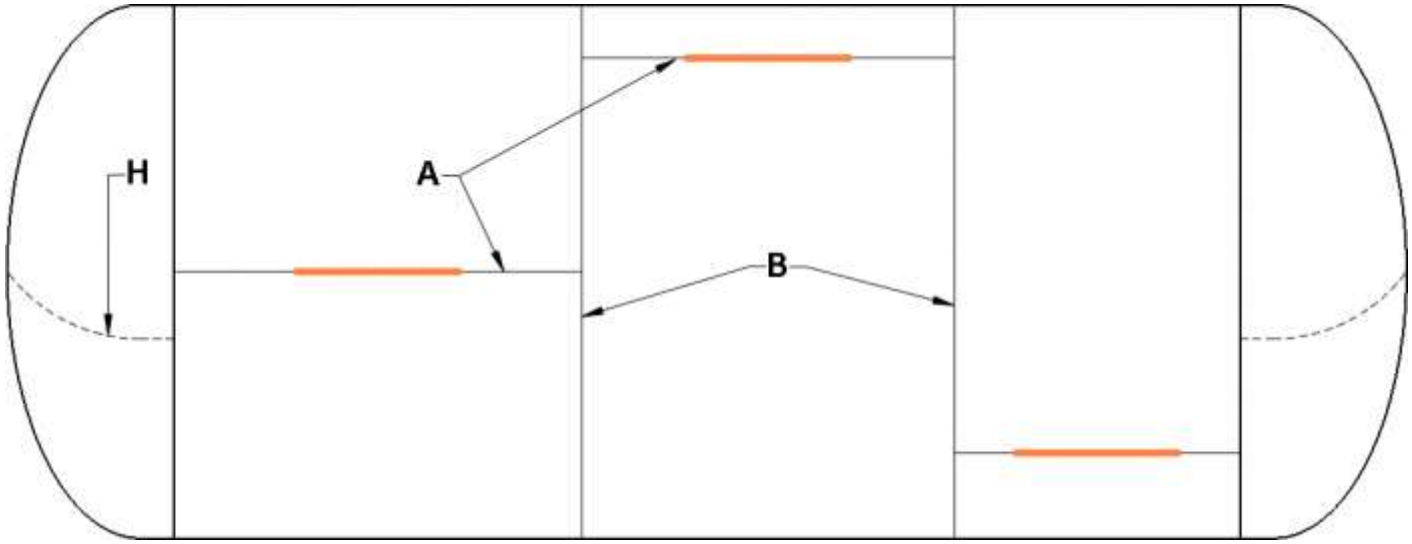


***Figure 2**. Sample vessel illustrating joint locations for RT-4 that will improve the shell long seam joint efficiency.*

Since circumferential stress governs cylindrical shell design, performing spot radiography on long seams is the easiest way to improve joint efficiency and thus reduce shell thickness.

When specified, spot radiography requires one examination for every 50 feet of the same type of weld, with the provision that each welder's work is represented. One spot could cover all of the Type 1 joints in this vessel if their total length adds up to less than 50 ft. This increases the long seam efficiency from 0.70 to 0.85 and reduces the cylindrical shell thickness at minimal cost.

The head imaginary joint efficiency remains at 0.85 due to UW-12(d).

RT-3

ASME PTB-4 Ref. No.: E7.3

 E = 0.85

 E = 0.85

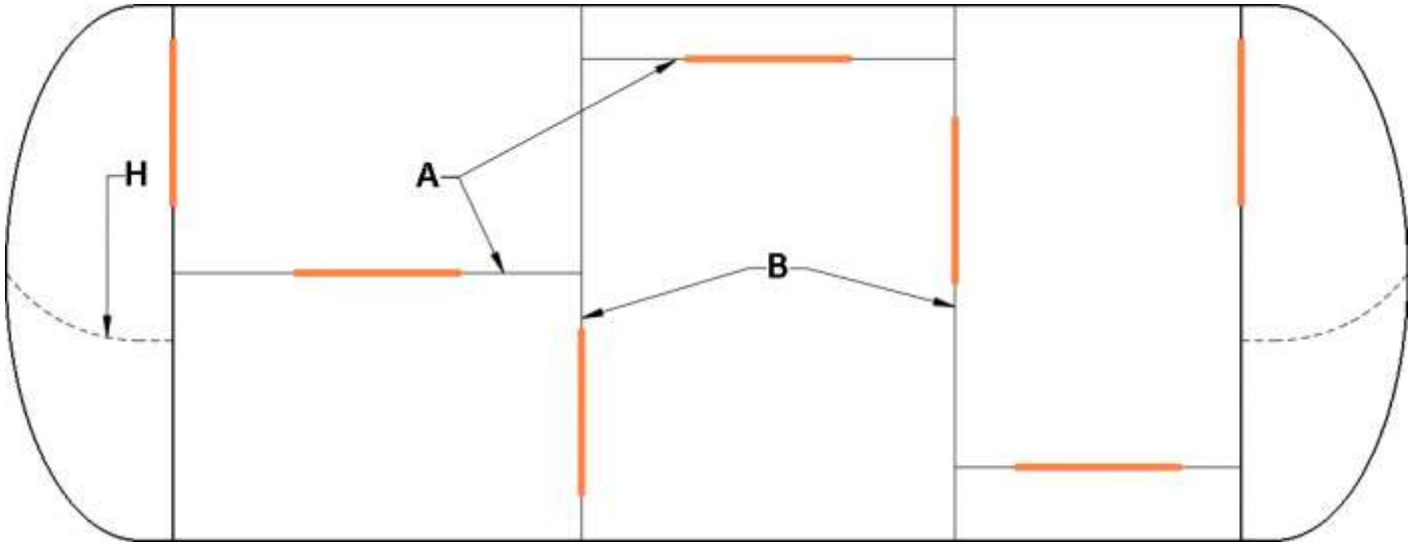


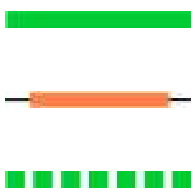
***Figure 3**. Sample vessel illustrating joint locations for RT-3 that will yield the same results as RT-4 Option 1.*

RT-3 increases the inspection requirements to spot radiography on both the long and circumferential seams of a vessel. There is no value added for the spot radiography of the circumferential joints since the long seam joint efficiency governs the design and RT-4 Option 1 already increased the long seam efficiency to 0.85.

The head imaginary joint efficiency remains at 0.85 due to UW-12(d).

RT-2

ASME PTB-4 Ref. No.: E7.2



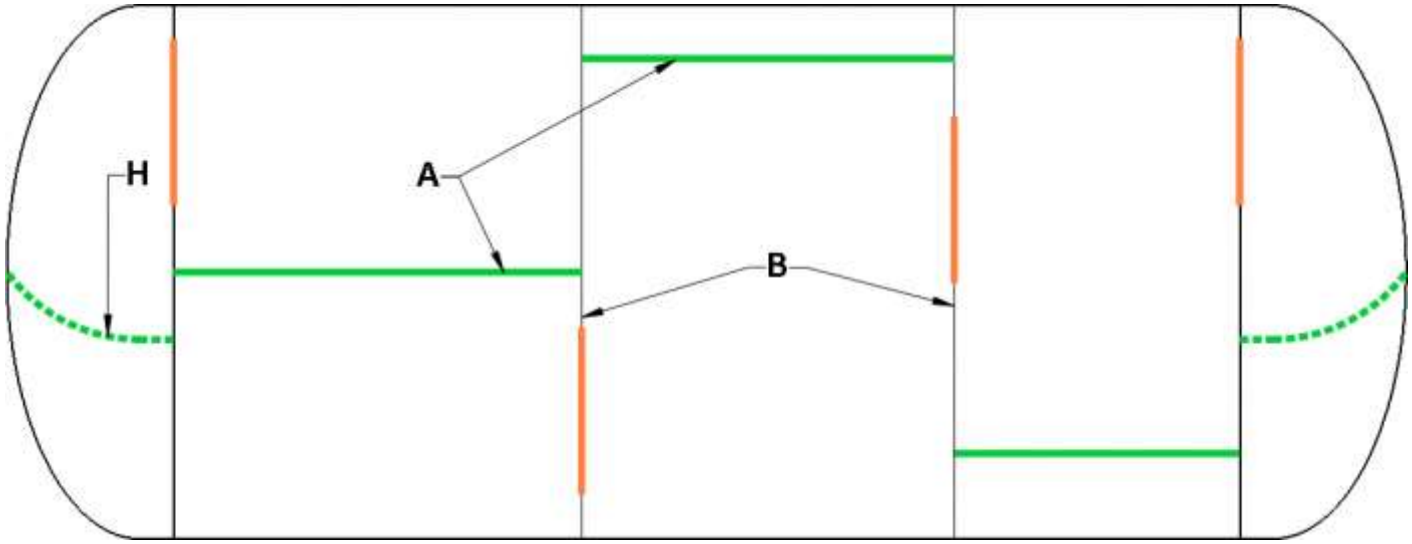


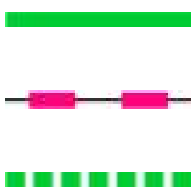
***Figure 4**. Sample vessel illustrating joint locations for RT-2 that will improve the shell long seam and head joint efficiency relative to RT-4 Option 1 and RT-3.*

RT-2 is often used to reduce the thickness of a seamless, non-hemispherical head by improving the head joint efficiency – all long seams must be fully examined to take advantage of this option.

For the first time rule UW-12(d) is met and the shell long and imaginary head seam efficiencies are 1.00.

RT-4 Option 2

ASME PTB-4 Ref. No.: E7.4



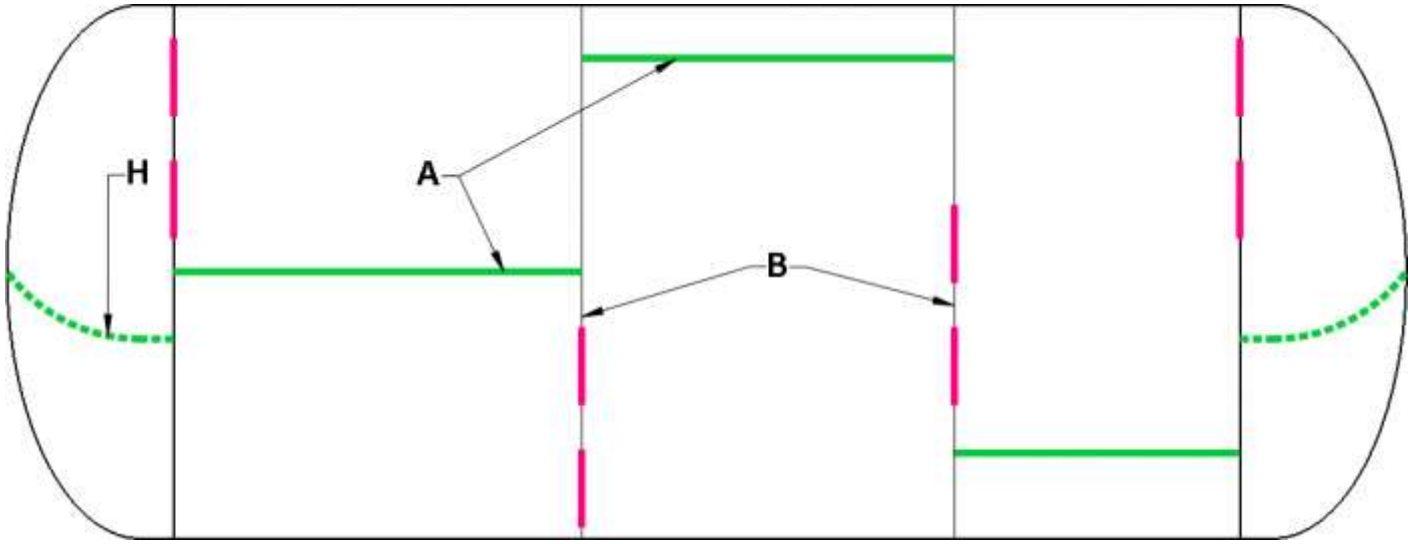


***Figure 5**. Sample vessel illustrating joint locations for RT-4 Option 2 that will improve the shell circumferential seam joint efficiency relative to RT-2.*

RT-4 Option 2 is similar to RT-2, but uses additional spot radiography to improve the circumferential joint efficiency of the shell. This option costs more than RT-2 and yields the same component thicknesses – circumferential seams do not govern the design of cylindrical shells.

Again rule UW-12(d) is met and the shell long and imaginary head seam efficiencies are 1.00.

RT-1

ASME PTB-4 Ref. No.: E7.1

E = 1.00

E = 1.00

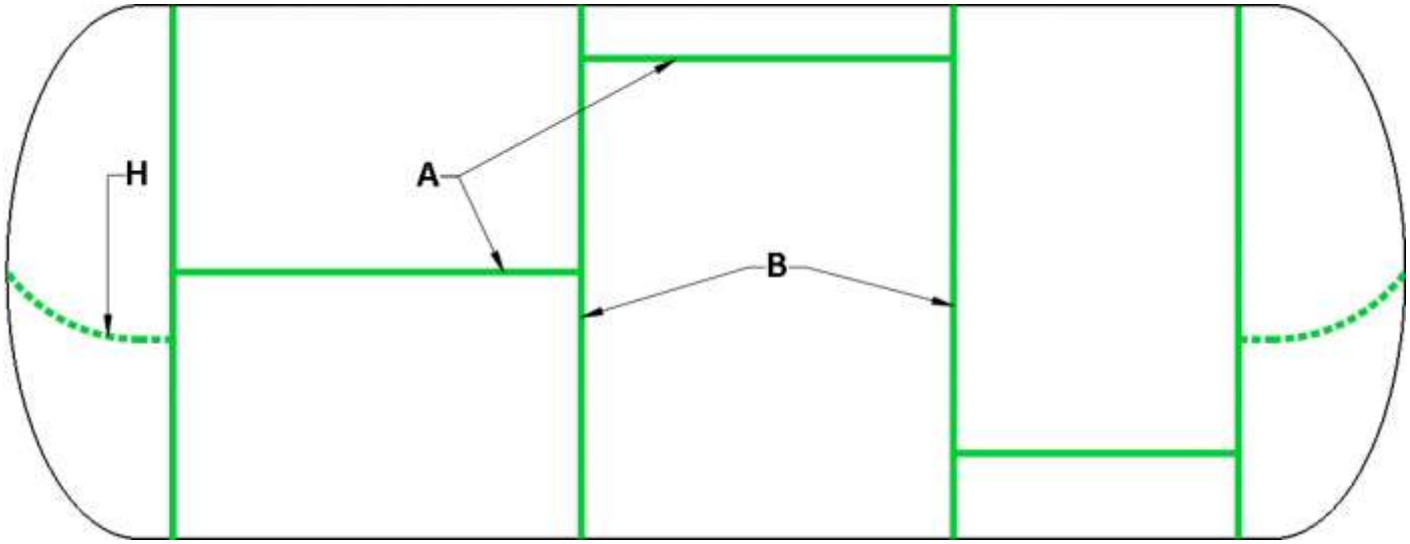
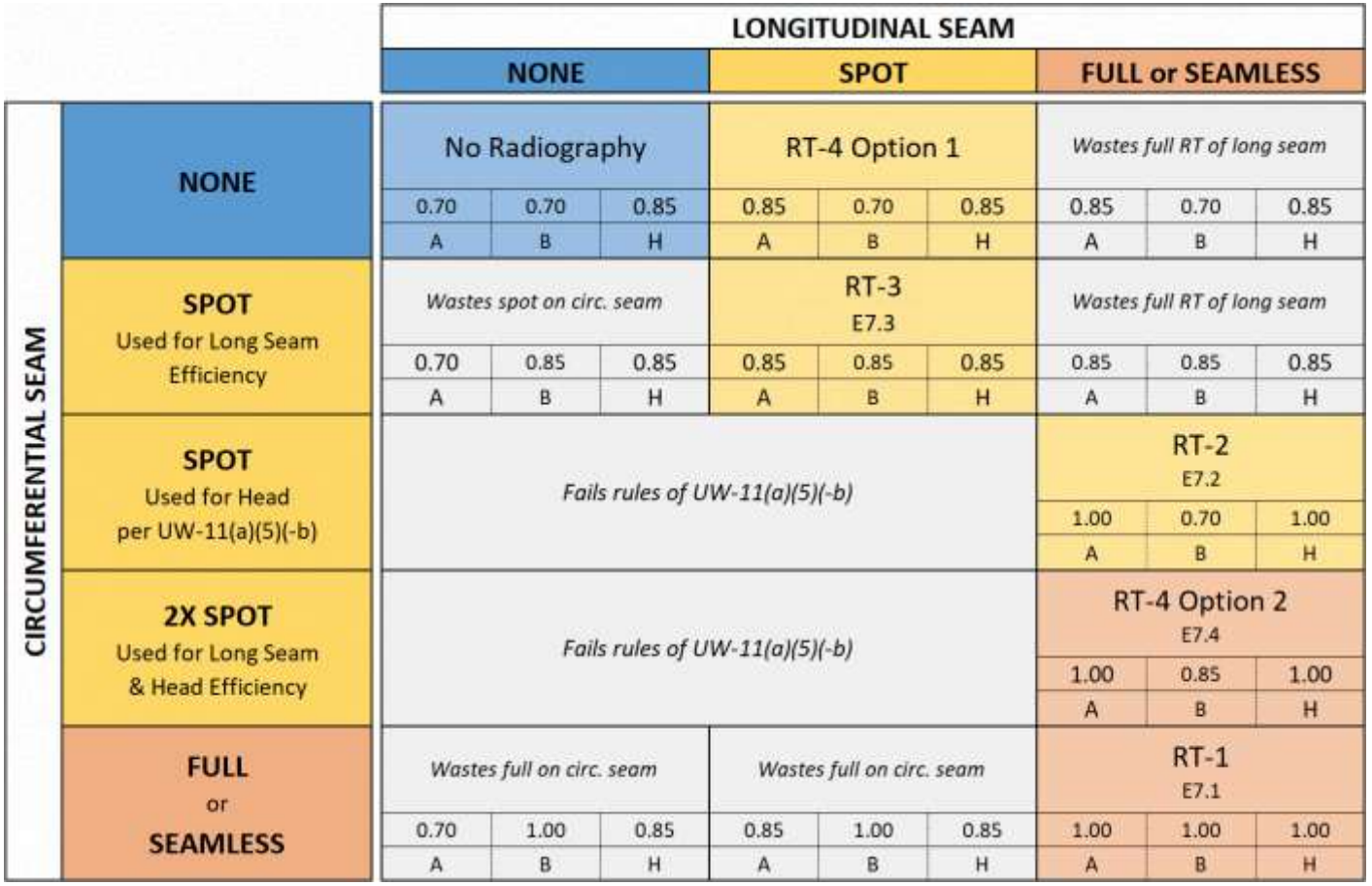


***Figure 6**. Sample vessel illustrating full radiography of all seams.*

As shown, RT-1 requires all seams to be examined for their full length and yields E = 1.00 for all joints. RT-1 inspection is required for lethal service.

Table 1. Summary of joint efficiencies for Type 1 joints on shells and seamless heads.



CIRCUMFERENTIAL SEAM	LONGITUDINAL SEAM: NONE			LONGITUDINAL SEAM: SPOT			LONGITUDINAL SEAM: FULL or SEAMLESS		
NONE	No Radiography			RT-4 Option 1			*Wastes full RT of long seam*		
	0.70	0.70	0.85	0.85	0.70	0.85	0.85	0.70	0.85
	A	B	H	A	B	H	A	B	H
SPOT Used for Long Seam Efficiency	*Wastes spot on circ. seam*			RT-3 E7.3			*Wastes full RT of long seam*		
	0.70	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
	A	B	H	A	B	H	A	B	H
SPOT Used for Head per UW-11(a)(5)(-b)	*Fails rules of UW-11(a)(5)(-b)*						RT-2 E7.2		
							1.00	0.70	1.00
							A	B	H
2X SPOT Used for Long Seam & Head Efficiency	*Fails rules of UW-11(a)(5)(-b)*						RT-4 Option 2 E7.4		
							1.00	0.85	1.00
							A	B	H
FULL or **SEAMLESS**	*Wastes full on circ. seam*			*Wastes full on circ. seam*			RT-1 E7.1		
	0.70	1.00	0.85	0.85	1.00	0.85	1.00	1.00	1.00
	A	B	H	A	B	H	A	B	H

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