11.D8 A forty-four millimeter (one and three-quarter inch) diameter cylindrical steel specimen is to be heat treated such that the microstructure throughout will be at least 50% martensite. We are to decide which of several alloys will satisfy this criterion if the quenching medium is moderately agitated (a) oil, and (b) water.

(a) Since the cooling rate is lowest at the center, we want a minimum of 50% martensite at the center position. From Figure 11.17(b), the cooling rate is equal to an equivalent distance from the quenched end of 13 mm (9/16 in.). According to Figure 11.14, the hardness corresponding to 50% martensite for these alloys is 42 HRC. Thus, all we need do is to determine which of the alloys have a 42 HRC hardness at an equivalent distance from the quenched end of 13 mm (9/16 in.). At an equivalent distance of 13 mm, the following hardnesses are determined from Figure 11.14 for the various alloys.

Alloy	Hardness (HRC)
4340	55
4140	52
8640	47
5140	41
1040	23

Thus, only alloys 4340, 4140 and 8640 will qualify.

(b) For moderately agitated water, the cooling rate at the center of a 44 mm (1-3/4 in.) diameter specimen is 9 mm (11/32 in.) equivalent distance from the quenched end [Figure 11.17(a)]. At this position, the following hardnesses are determined from Figure 11.14 for the several alloys.

Alloy	Hardness (HRC)
4340	57
4140	55
8640	53
5140	48
1040	30

It is still necessary to have a hardness of 42 HRC or greater at the center; thus, alloys 4340, 4140, 8640, and 5140 qualify.