NUCOR
STEEL SEATTLE, INC.

Safe Job Procedure
Standard Practice

Title	Casting Dissimilar Grades	
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Revision #	3	

Safety Apparel, Tools or Equipment Needed;

Hard Hat	Glasses w/ Side Shields	Steel Toed Boots w/ Metatarsals
Ear Plugs	Coverall and/or Greens	

Sequential Description of the Procedure	**Hazards / Quality Impact**
1. When sequencing dissimilar grades, we have three choices. **Category 1:** Gradually change the chemistry from one grade to another and use the transition billets for one of the two grades. An example is when going from A615 Gr 40 to A615 Gr 60 (for the same or similar bar size), A706 Gr 60 (for any bar size), or Nucor Multigrade. Except in very unusual cases, the transition billets will be suitable for A615 Gr 40. **Category 2:** Similar to category one, except that the transition billets (generally the last eight of the first heat and the first eight of the following heat) aren't suitable for either grade, but they can be used for a different [prime] grade. An example is when we go from A36A5295044W50W to A615 Gr 60, in which case the sixteen transition billets can almost always be used for A615 Gr 40. **Category 3:** ***Which is to be avoided as much as possible***, cast dissimilar grades without concern for a drastic change in chemistry and designate the transition billets as NG ("No Grade"). This is the case when we cast A615 Gr 80 followed by Nucor Multigrade or A36A5295044W50W, or vice versa.	"Transition billets" are defined as those billets that we get from the mixture of the two different grades in the tundish. Care must be taken to ensure that transition billets get identified and applied to a suitable grade, or the product will not meet the ASTM , CSA, or customer requirements to which it will be certified.

EXAMPLES

Note: The following examples assume that all four strands are being used. If the caster is on three strands, make three transition billets per strand, for a total of nine billets.

	FROM	CASTING DIRECTION	TO
A	**A36A5295044W/50W**	⇒⇒⇒⇒⇒⇒⇒	**A615 Gr 40**

For the A36A5295044W/50W heat, change the cut length of the last two billets per strand to the length for the next heat. Designate those billets as A615 Gr 40. Sample the east end of the ninth billet from the end of the A36A5295044W/50W heat to ensure that it conforms to the A36A5295044W/50W specification, thereby keeping this grade "clean." (This is referred to as "subtracting two per strand.")

B	**A615 Gr 40**	⇒⇒⇒⇒⇒⇒⇒	**A36A5295044W/50W**

Continue cutting at the A615 Gr 40 length until two billets per strand of the new A36A5295044W/55W have been made. Sample the east end of the eighth billet of the new heat to ensure that it conforms to the A36A5295044W/55W specification, and designate those first eight billets as A615 Gr 40. (This is referred to as "adding two per strand.")

C	**A529 Gr 50 (no V or Cb)**	⇒⇒⇒⇒⇒⇒⇒	**A36A5295044W/50W**

Note that A529 Gr 50 is one of the grades included in A36/A5295044W/50W combination grade (sometimes called "4-way"). In most cases*, *add* two billets per strand and take a sample to confirm the chemistry, just as in example B above.

*Depending on the chemistry and the bar size designated for heats of these two grades, sometimes it may be okay to just do a normal transition, and there may even be cases where you would *subtract* two per strand. The critical points are:

1. A529 Gr 50 has a higher maximum allowed tensile strength than does the A36/A5295044W/50W combination grade, even though the minimum yield strength requirement (50,000 PSI) is the same. Therefore, not all A529 Gr 50 heats can be certified to meet A36/A5295044W/50W. This is why A36/A5295044W/50W generally needs to be kept "clean."
2. Tensile properties are determined by both the chemistry and the processing conditions [temperature; number of stands being used; cooling rate after the bars land on the bed]. Everything else being equal, smaller bar sizes have higher strength because they undergo more reduction and cool faster on the cooling bed. Therefore, a heat intended to meet A529

	Gr 50 may not meet A36/A5295044W/50W in the same bar size, and an A36/A5295044W/50W heat for one size may not meet either grade in a different bar size.
D	**A36A5295044W/50W ⇒⇒⇒⇒⇒⇒ A529 Gr 50 (no V or Cb)** ⇒ These are the same two grades as in example C, but in the opposite direction. Unless it's one of the occasions where the transition billets will meet both grades, treat this like example B; in other words, add two per strand to keep the A529 Gr 50 "clean," and get a billet sample.
E	**A529 Gr 50 (no V or Cb) ⇒⇒⇒⇒⇒⇒ A615 Gr 40** ⇒ Subtract two billets per strand from the A529 and sample the east end of the last billet, so as to keep the A529 clean. This is because all A529 grades (whether or not they require V or Cb) have more restrictive chemistry requirements (and a higher minimum yield strength requirement) than does A615 Gr 40. The only exception for this example is if the A615 Gr 40 heat happens to have low enough C, Mn, S, and P that it meets A529 Gr 50.
F	**A615 Gr 40 ⇒⇒⇒⇒⇒⇒ A529 Gr 50 (no V or Cb)** ⇒ This is the same as example E, but in the reverse direction. Add two billets per strand to the A615 40 and sample the east end of the last A615 40 billet to ensure that the A529 is kept clean.
G	**A615 Gr 40 ⇒⇒⇒⇒⇒⇒ A529 Gr 50 (with V or Cb)** ⇒ Add two billets per strand to the A615 Gr 40 and sample the east end, just like in example F. The presence of a V or Cb requirement for A529 Gr 50 only affects how you would handle sequencing it with another merchant bar grade, not a rebar grade.
H	**1527 FG ⇒⇒⇒⇒⇒⇒ A706 (or DG) 60** ⇒ Many grade combinations fit into two of the categories defined in the first step of this procedure. The sequence of a 1527 FG heat to A706 Gr 60 or A615/A706 Gr 60 is one such example. Because 1527 FG has a more restrictive chemistry than most of the grades that we produce, it's always a priority to keep this grade clean. Whether the transition billets are suitable for A706 or A615/A706 Gr 60 depends on the rebar size for which the second heat is designated. Almost always, a 1527 FG heat will be suitable for DG60_8 through DG60_11, because our internal spec

	for Mn is very close the 1.30-1.40 Mn range for 1527 FG. Therefore, when making billets for rebar sizes #8 through #11, subtract two billets per strand from the 1527 FG heat, get a billet sample, and designate the last two billets per strand to be the same grade as the following heat. However, for rebar sizes smaller than #7 bar, the 1527 Mn requirement is increasingly likely to be too high, while for #14 and #18 rebar, the CE may not be quite high enough to ensure a passing tensile test result. This latter case falls into category 2, where the last two billets per strand of the 1527 FG heat, and the first two billets per strand of the A706 heat, have to be used for a different grade; A615 Gr 60 being the most likely candidate.

	FROM CASTING DIRECTION TO
I	**A615 Gr 60 & 400R ⇒⇒⇒⇒⇒⇒⇒ A615 Gr 60 & 400R** **(all bar sizes) (all bar sizes)** This scenario is similar to the one in example H. Although P is the only element that has an ASTM or CSA requirement, our internal "floating" chemistry aims vary gradually with bar size. The bigger the difference between the bar sizes of the two heats involved in this transition, the more likely it is that the transition billets will be suitable for one size but not the other. If the two heats are for bar diameters that differ by a half-inch or more (#5 to #9, for example), it becomes increasingly likely that the last two billets per strand of the first heat and the first two billets per strand of the second heat will need to be designated for an intermediate bar size. For example, if going from #4 to #9, a good option for the transition billets would be #7. The bottom line is, the lab tech needs to look at the specs for the bar sizes involved in the transition, and make the best possible judgment for how to handle it.
J	**A615 60 & 400R ⇒⇒⇒⇒⇒⇒⇒ A615 Gr 40** **(all rebar sizes)** In this example, always cut-off the first heat two billets early per strand and request a sample. Whether the transition billets can be applied to A615 Gr 40 depends on the chemistry of the first heat. In general, if the first heat is for #6 rebar or smaller, the transition billets will be okay for A615 Gr 40. But if C or the overall CE is too high, then the transition billets will have to be designated for NG.
K	**A706 & 400W ⇒⇒⇒⇒⇒⇒⇒ A615 60 & 400R** **(All Sizes) (All Sizes)** Subtract two billets per strand from the A706 (or 400W); sample the east end of the last billet, thereby keeping the A706 (or 400W) clean. In most cases, the transition billets will be suitable for A615 Gr 60 or 400R. However, be careful with A706 Gr 60 for bar sizes #3-#5, or for any 400W heat. That's because both A706 Gr 60 and 400W have a significantly lower minimum tensile strength requirement than does A615 Gr 60. [This concern doesn't apply to the DG60 bar sizes (#6 through #11), because they have to meet the higher tensile requirement.] But if the A706 heat is for #3, #4, or #5, the transition billets may not have a high enough chemistry to ensure they'll meet the A615 Gr 60 tensile requirement.

3. When one of the above combinations is sequenced, the casting personnel will add or subtract one or two billets per strand to the heat, depending on which order the two grades are cast and as shown above. (See illustration A)	(Q) It is the Responsibility of the Lab Tech to ensure the integrity of the steel and to communicate with the Torch Operator what needs to be done.
4. Depending on whether the two billets per strand are being added or subtracted, the eight transition billets	(Q) Only in the most extreme cases or when doubt is present, do we

	will be the same ones that the Torch Operator chalk-marks "XXXXabcd" or "abcdOOOO", where "abcd" represents the last four digits of the heat number. (See SJP-0004-QCA, "Heat Identification & Traceability.") This procedure assumes that the eight transition billets consist of two billets per strand. However, if billets from one of the strands get "bunched up" on the roll line, this could cause the mixed-chemistry billets to reach the cooling table out of sequence, and one or more of the mixed-chemistry billets could mistakenly get included with the grade that is most chemistry-sensitive. The Torch Operator is responsible for watching the billets emerge from the caster and preventing an undesired grade-mix by ensuring that it is the eight transition billets that are used for heat identification. Deviations from this outcome shall be reported to the Lab Tech.	need to obtain a minimum of eight samples to ensure the quality of our steel. If any doubt remains, the Lab Tech must designate in QMOS the appropriate number of billets as NG (or a more appropriate grade) until clarification can be made. The Scheduler needs to notified of these events. Burns because of being too close to very hot steel. Sparks from the cutting torch Moving billets in the roll table
	Refer to IFS document ***"Sequencing Dissimilar Grades" SPC-0028-QCA*** on where to take billet samples to verify that the transition billets meet the grade requirements of the heat with which they were included. If the grade combination is not represented on the chart, instructions will be supplied by the Q.C. Department.	
6.	All necessary samples must be taken and analyzed as quickly as possible. If the billet sample reveals chemistry different than what was expected, the billet crane operator will set the "X" and "O" billets aside for additional sampling.	(Q) A mix of dissimilar grades can cause a failure in the final product
	CATEGORY 2	
7.	**Category 2** (see Item #1) occurs when any other combination of dissimilar grades are sequenced, and the result will be transition billets that cannot be used as graded material.	
8.	The procedure is to automatically put these transition billets to NG, as follows: When sequencing two very dissimilar grades (such as A36A5295044W/50W and A615 Gr 60), the torch operator will count one transition billet per each heat per strand. Assuming all four strands are operating, this will make a total of 8 billets. These billets are to be cut to 28'0" and set aside. The remaining eight transition billets from each heat will be the ones marked "abcdOOOO" or "XXXXabcd" and steps 6 & 7 above shall apply. Note that for this category of	

very dissimilar grade combinations, illustration B in SPC-0028-QCA applies. This requires each billet to be identified with the strand number, in case additional billets need to be sampled.	
9. Billet samples from each NG billet are to be cut promptly sent to the lab for analysis. One of the billet samples will be cut in each strand from the front of the first NG billet and another one in each strand from the tail of the second NG billet (see SPC-0028-QCA).	
10. The billet samples must be cut and analyzed as quickly as possible, after the NG billets have been picked up with the magnet from the run out table.	
11. For production purposes, half of the NG billets will be credited to each heat. Again, the samples are to be sent promptly to the lab.	
12. For sequencing Grade 1080 with any of our regular grades including A615 Gr 60, the dissimilarity is so big that it requires double the amount of NG transition billets. In addition, the casting personnel should allow the level of steel in the tundish to fall in order to minimize the mixing of the two grades. The casting personnel will count two transition billets per each heat per each strand. Assuming all four strands are operating and the billet size is 160mm, this will make a total of 16 billets. These billets are to be cut to 28'0" and set aside as NG.	Don't allow the level in the tundish to fall to the point where there is a risk of missing the sequence.
13. If in any of all the above conditions for both Category 1 & 2, the tests reveal that the heats are not within the desired chemistries more billet testing is required, keeping track at all times what billets and ends the samples come from	A billet rolled into a grade that is not intended can cause a catastrophic failure
14. No grade billets that are not suitable for mill sizing billets will be identified by marking the tops as "Scrap", and painting the ends with red paint after the billets have cooled.	
15. For cross application of reheat billet, see IFS document ***SPC-0014-QCA "Matrix Showing Products for Which Reheats Can Be Charged"***	