
ENGINEERING
DESIGN & ANALYSIS

1
00:01:08,870 --> 00:01:05,000
welcome I'm very pleased to introduce

2
00:01:12,170 --> 00:01:08,880
mr. rich Barrett and the fastener design

3
00:01:14,570 --> 00:01:12,180
course rich as you may well know it's a

4
00:01:15,470 --> 00:01:14,580
NASA engineer he has been an engineer

5
00:01:18,200 --> 00:01:15,480
for 40 years

6
00:01:22,880 --> 00:01:18,210
and up with the Lewis Research Center

7
00:01:25,570 --> 00:01:22,890
for 34 of those 40 years he's advised in

8
00:01:30,950 --> 00:01:25,580
the materials and the materials of

9
00:01:33,859 --> 00:01:30,960
fasteners and materials is well sought

10
00:01:37,850 --> 00:01:33,869
by industry and by other government

11
00:01:41,050 --> 00:01:37,860
agencies besides NASA he's faster design

12
00:01:46,219 --> 00:01:41,060
Manuel has received widespread acclaim

13
00:01:48,800 --> 00:01:46,229

and distribution and it led to his

14
00:01:51,190 --> 00:01:48,810
earning of the federal laboratory

15
00:01:53,930 --> 00:01:51,200
consortium award for technology transfer

16
00:01:57,080 --> 00:01:53,940
all the awards that mr. Barrett has

17
00:02:00,590 --> 00:01:57,090
received our de NASA exceptional service

18
00:02:03,680 --> 00:02:00,600
medal and the Eldar statement of a VA

19
00:02:06,200 --> 00:02:03,690
ssin award with not much more to say

20
00:02:09,470 --> 00:02:06,210
here is mr. rich Barrett thank you very

21
00:02:12,949 --> 00:02:09,480
much thank you Mario for the nice

22
00:02:17,270 --> 00:02:12,959
introduction we will be presenting in

23
00:02:21,470 --> 00:02:17,280
this course one of the it will be the

24
00:02:23,840 --> 00:02:21,480
most extensive coverage is fastener

25
00:02:30,440 --> 00:02:23,850
design that I have done to date because

26
00:02:35,380 --> 00:02:30,450
it will be a about 385 pages of

27
00:02:37,940 --> 00:02:35,390
presentation so we will move into it and

28
00:02:40,430 --> 00:02:37,950
unless they say in the candy commercial

29
00:02:43,250 --> 00:02:40,440
you're not going anywhere for a while so

30
00:02:46,509 --> 00:02:43,260
relax and we'll cover everything we can

31
00:02:50,840 --> 00:02:46,519
on fasteners thank you

32
00:02:52,850 --> 00:02:50,850
so to start out with I'd like to give

33
00:02:56,750 --> 00:02:52,860
you some acknowledgments year of the

34
00:03:00,620 --> 00:02:56,760
people that had a hand in this will

35
00:03:03,350 --> 00:03:00,630
Harkins and Mario Castro Mario is my

36
00:03:07,730 --> 00:03:03,360
boss here at NASA Lewis will Harkins

37
00:03:10,160 --> 00:03:07,740
from NASA headquarters sponsored this

38
00:03:11,940 --> 00:03:10,170

course funded quite a bit of it

39
00:03:14,699 --> 00:03:11,950
so this will

40
00:03:18,300 --> 00:03:14,709
used by all of the different NASA

41
00:03:20,309 --> 00:03:18,310
centers Harold Casper from Analects

42
00:03:22,800 --> 00:03:20,319
corporation he wrote some of the

43
00:03:24,750 --> 00:03:22,810
sections and found some information for

44
00:03:28,260 --> 00:03:24,760
the others as well as editing the entire

45
00:03:30,600 --> 00:03:28,270
course John Bickford who is the leading

46
00:03:33,720 --> 00:03:30,610
author actually in the fastener field

47
00:03:35,670 --> 00:03:33,730
he is the editor-in-chief of a book

48
00:03:38,070 --> 00:03:35,680
which I was contributing author horribly

49
00:03:40,710 --> 00:03:38,080
published the end of the year I used a

50
00:03:44,100 --> 00:03:40,720
lot of John's stuff from his book on

51
00:03:47,900 --> 00:03:44,110
fastener design in this course being

52
00:03:50,820 --> 00:03:47,910
blend off from Clemson University and

53
00:03:53,699 --> 00:03:50,830
he's actually chairman of the bolting

54
00:03:56,130 --> 00:03:53,709
technology Council which is a council

55
00:04:00,180 --> 00:03:56,140
dedicated to furthering the knowledge on

56
00:04:06,090 --> 00:04:00,190
fastener design has contributed some and

57
00:04:09,210 --> 00:04:06,100
Betsy dela Cruz who did all of the

58
00:04:11,160 --> 00:04:09,220
typing retyping running someone to get

59
00:04:13,740 --> 00:04:11,170
this thing together and we just about

60
00:04:15,150 --> 00:04:13,750
ran out of time but that's why we did

61
00:04:17,729 --> 00:04:15,160
not give it before and I say it's

62
00:04:20,340 --> 00:04:17,739
approximately a two-day course then

63
00:04:22,920 --> 00:04:20,350

rehoming from atf corporation edited the

64
00:04:24,719 --> 00:04:22,930
entire course and had some very helpful

65
00:04:26,790 --> 00:04:24,729
comments so with that in mind we'll

66
00:04:31,110 --> 00:04:26,800
proceed with the little introductory

67
00:04:34,500 --> 00:04:31,120
material now there's a statement

68
00:04:37,380 --> 00:04:34,510
everybody knows about bolts and nuts but

69
00:04:40,529 --> 00:04:37,390
do they really know about bolts and nuts

70
00:04:41,969 --> 00:04:40,539
sometimes we oversimplify things because

71
00:04:44,580 --> 00:04:41,979
we think because it's something that a

72
00:04:50,900 --> 00:04:44,590
kid took off the wagon that it's simple

73
00:04:57,560 --> 00:04:54,460
the Joseph Dudley who is a

74
00:05:00,470 --> 00:04:57,570
vice-president of automotive marketing

75
00:05:03,950 --> 00:05:00,480
for nighlok passenger corporation gave

76
00:05:06,350 --> 00:05:03,960
these two quotes 75% of the assembly

77
00:05:10,630 --> 00:05:06,360
labor cost of an automobile is spent on

78
00:05:13,400 --> 00:05:10,640
fasteners and 80 to 85 percent of all

79
00:05:15,200 --> 00:05:13,410
automobile recalls or fastener related

80
00:05:16,760 --> 00:05:15,210
now that gives you an idea about the

81
00:05:18,800 --> 00:05:16,770
importance of fasteners and putting

82
00:05:20,840 --> 00:05:18,810
things together and of course some of

83
00:05:22,730 --> 00:05:20,850
you remember on the shuttle recently

84
00:05:24,620 --> 00:05:22,740
when they had to cancel a spacewalk

85
00:05:26,810 --> 00:05:24,630
because a couple screws came loose and

86
00:05:27,470 --> 00:05:26,820
fell out in the gears they couldn't get

87
00:05:31,370 --> 00:05:27,480
the door open

88
00:05:34,610 --> 00:05:31,380

so things do go wrong like that here is

89
00:05:37,370 --> 00:05:34,620
a summary of the causes for joint

90
00:05:39,170 --> 00:05:37,380
failures and NASA's Skylab program some

91
00:05:42,250 --> 00:05:39,180
of you say Ron Roman Chuck would

92
00:05:46,790 --> 00:05:42,260
remember that he was here that that poem

93
00:05:50,120 --> 00:05:46,800
back when that happened and the thing

94
00:05:55,060 --> 00:05:50,130
that surprised me in this is the poor

95
00:05:59,000 --> 00:05:55,070
design improper assembly here

96
00:06:02,030 --> 00:05:59,010
24% poor design 28% for improper

97
00:06:05,330 --> 00:06:02,040
assembly and yet only 10% for bad parts

98
00:06:08,360 --> 00:06:05,340
and the 24% for parts damaged in

99
00:06:12,020 --> 00:06:08,370
handling and the wrong preload 14% now

100
00:06:16,460 --> 00:06:12,030
we have been hearing in the news for the

101
00:06:19,700 --> 00:06:16,470
past several years about the counterfeit

102
00:06:21,440 --> 00:06:19,710
fasteners and all of that and so it's

103
00:06:25,100 --> 00:06:21,450
gotten quite a bit of publicity and it

104
00:06:28,520 --> 00:06:25,110
should but it still boils down to the

105
00:06:29,380 --> 00:06:28,530
fact that the designer has more to do

106
00:06:32,660 --> 00:06:29,390
with it

107
00:06:35,750 --> 00:06:32,670
then the manufacture of the fasteners

108
00:06:39,800 --> 00:06:35,760
now here is a something from John

109
00:06:42,200 --> 00:06:39,810
Bickford book on a bolted joint just a

110
00:06:44,780 --> 00:06:42,210
spring concept because actually you

111
00:06:47,120 --> 00:06:44,790
don't think of it this way but a the

112
00:06:49,580 --> 00:06:47,130
joint material itself is a big heavy

113
00:06:51,680 --> 00:06:49,590

spring and you're compressing it with

114
00:06:54,700 --> 00:06:51,690
small Springs which are fasteners and we

115
00:06:57,710 --> 00:06:54,710
even get into joint stiffness and

116
00:07:00,530 --> 00:06:57,720
stiffness ratios and so on now here is a

117
00:07:03,160 --> 00:07:00,540
summary of the different types of heads

118
00:07:09,820 --> 00:07:03,170
on fasteners just to

119
00:07:11,710 --> 00:07:09,830
for your reference and these this is use

120
00:07:13,390 --> 00:07:11,720
some in the aerospace field although

121
00:07:16,960 --> 00:07:13,400
it's not that common but of course the

122
00:07:21,820 --> 00:07:16,970
flat the socket head over here and the

123
00:07:24,490 --> 00:07:21,830
hex all of these are very common the

124
00:07:28,150 --> 00:07:24,500
carriage bolt of course that one is I

125
00:07:29,980 --> 00:07:28,160
guess dates back to the building wagons

126
00:07:31,840 --> 00:07:29,990
when you drilled a hole and you pounded

127
00:07:34,270 --> 00:07:31,850
that one in and the square part under

128
00:07:36,640 --> 00:07:34,280
the head there locked it in place where

129
00:07:38,260 --> 00:07:36,650
you put the nut on so Betsy that's how

130
00:07:40,620 --> 00:07:38,270
you build wagons in case you ever go

131
00:07:45,280 --> 00:07:40,630
into it

132
00:07:49,750 --> 00:07:45,290
here's one on the internal drive systems

133
00:07:52,060 --> 00:07:49,760
and you can't read it too well on on

134
00:07:54,100 --> 00:07:52,070
this one but over on the view graphs I

135
00:07:57,730 --> 00:07:54,110
think you can read them and a lot of

136
00:08:01,120 --> 00:07:57,740
these are common only to the aerospace

137
00:08:05,740 --> 00:08:01,130
world like for instance something like

138
00:08:12,040 --> 00:08:05,750

this or something like the Tri wing type

139
00:08:15,520 --> 00:08:12,050
here these are used only by certain

140
00:08:19,180 --> 00:08:15,530
manufacturers the torques down here is

141
00:08:22,720 --> 00:08:19,190
very common in the automotive field that

142
00:08:26,590 --> 00:08:22,730
one I thought that I'm always looking at

143
00:08:29,920 --> 00:08:26,600
conspiracy theories of designers and I

144
00:08:32,890 --> 00:08:29,930
thought the torques was developed by the

145
00:08:34,900 --> 00:08:32,900
automotive people just to make things

146
00:08:37,450 --> 00:08:34,910
more difficult on working on your car

147
00:08:40,420 --> 00:08:37,460
but I found out that the reason they use

148
00:08:44,290 --> 00:08:40,430
it was that it centers better than the

149
00:08:48,190 --> 00:08:44,300
Philips which various types of Philips

150
00:08:51,060 --> 00:08:48,200
there and will not came out as much so

151
00:08:55,420 --> 00:08:51,070
therefore it will work better in

152
00:08:59,890 --> 00:08:55,430
automated assembly now getting into the

153
00:09:02,140 --> 00:08:59,900
agenda for this program see we have a

154
00:09:06,490 --> 00:09:02,150
lot of stuff and each one of these is a

155
00:09:08,710 --> 00:09:06,500
section number in your handout so we

156
00:09:13,150 --> 00:09:08,720
have a lot of stuff here to cover I

157
00:09:16,250 --> 00:09:13,160
won't go over all of these but I'll

158
00:09:17,900 --> 00:09:16,260
point out that at the end we have a do

159
00:09:20,960 --> 00:09:17,910
and don'ts and frequently asked

160
00:09:23,210 --> 00:09:20,970
questions sections that that will answer

161
00:09:25,310 --> 00:09:23,220
some of the various questions that I

162
00:09:30,850 --> 00:09:25,320
have been asked from time to time by

163
00:09:34,520 --> 00:09:30,860

people so we'll move on into materials

164
00:09:40,070 --> 00:09:34,530
and this this I feel is a very important

165
00:09:42,410 --> 00:09:40,080
section because you need to choose the

166
00:09:45,080 --> 00:09:42,420
right material to begin with or you're

167
00:09:47,330 --> 00:09:45,090
dead in the water on a design now

168
00:09:48,590 --> 00:09:47,340
fasteners can be made for many materials

169
00:09:51,110 --> 00:09:48,600
but most of them that we're familiar

170
00:09:54,860 --> 00:09:51,120
with are made out of steel the the

171
00:09:58,040 --> 00:09:54,870
hardware store tape that are made out of

172
00:10:01,400 --> 00:09:58,050
what's called low carbon steel then the

173
00:10:02,750 --> 00:10:01,410
alloy steel for the greatest fives and

174
00:10:05,180 --> 00:10:02,760
eights that we use around here in a

175
00:10:07,790 --> 00:10:05,190
socket head cap screw titanium and

176
00:10:09,860 --> 00:10:07,800
aluminum bolts have limited usage in the

177
00:10:14,840 --> 00:10:09,870
aerospace industry but on the other hand

178
00:10:18,770 --> 00:10:14,850
aluminum and titanium are used a lot on

179
00:10:20,600 --> 00:10:18,780
the aircraft design particularly since

180
00:10:25,880 --> 00:10:20,610
you have aluminum skins on most

181
00:10:29,260 --> 00:10:25,890
airplanes and you want the rivets to be

182
00:10:31,910 --> 00:10:29,270
of the same material because of the

183
00:10:35,680 --> 00:10:31,920
differential temperature giving you

184
00:10:39,740 --> 00:10:35,690
problems on expansion and contraction so

185
00:10:46,400 --> 00:10:39,750
now the alloy steel fasteners you can

186
00:10:48,230 --> 00:10:46,410
get them up to 300 ksi ksi being a

187
00:10:51,890 --> 00:10:48,240
thousand psi so it's three hundred

188
00:10:54,530 --> 00:10:51,900

thousand psi strength levels but I'll

189
00:10:56,630 --> 00:10:54,540
try to point out to you here that in

190
00:11:00,560 --> 00:10:56,640
most cases you really don't want to do

191
00:11:03,020 --> 00:11:00,570
that okay now carbon Steel's

192
00:11:04,880 --> 00:11:03,030
are not corrosion resistant so they

193
00:11:07,540 --> 00:11:04,890
usually have to have some kind of a

194
00:11:11,150 --> 00:11:07,550
coating to protect them from rusting and

195
00:11:14,750 --> 00:11:11,160
the stainless steels you can get in all

196
00:11:17,810 --> 00:11:14,760
all varieties of both heat treatable and

197
00:11:21,320 --> 00:11:17,820
non heat treatable alloys with the

198
00:11:23,600 --> 00:11:21,330
tensile strengths of 70 ksi to 260 the

199
00:11:25,660 --> 00:11:23,610
seventy being the ordinary 300 series

200
00:11:29,079 --> 00:11:25,670
stainless that we use here all the time

201
00:11:33,790 --> 00:11:29,089
and the 260 or

202
00:11:37,449 --> 00:11:33,800
talking work-hardened inconel 718 or

203
00:11:42,280 --> 00:11:37,459
eight to eighty six and note that the

204
00:11:45,400 --> 00:11:42,290
400 series materials contain only 12%

205
00:11:48,280 --> 00:11:45,410
chromium which will allow them to rust

206
00:11:51,009 --> 00:11:48,290
so if you're building something that you

207
00:11:54,670 --> 00:11:51,019
want it to look pretty the 400 series

208
00:11:56,920 --> 00:11:54,680
stainless would not be advisable and on

209
00:12:00,910 --> 00:11:56,930
some of these subsequent tables we will

210
00:12:04,059 --> 00:12:00,920
show various materials but just go on to

211
00:12:09,460 --> 00:12:04,069
the in order here on the selection and

212
00:12:11,319 --> 00:12:09,470
materials you should use common fastener

213
00:12:14,379 --> 00:12:11,329

materials strength levels and coatings

214
00:12:17,619 --> 00:12:14,389
if you can there's no sense in over

215
00:12:19,720 --> 00:12:17,629
killing on any design because it can

216
00:12:22,840 --> 00:12:19,730
just cost you money and time usually

217
00:12:24,939 --> 00:12:22,850
weight savings versus cost must also be

218
00:12:26,499 --> 00:12:24,949
evaluated for flight articles and there

219
00:12:30,160 --> 00:12:26,509
you do spend a lot of money to save a

220
00:12:32,590 --> 00:12:30,170
little bit of weight galvanic and stress

221
00:12:35,559 --> 00:12:32,600
corrosion tolerance levels have to be

222
00:12:38,530 --> 00:12:35,569
established and checked out and of

223
00:12:40,329 --> 00:12:38,540
course the operating temperatures has to

224
00:12:44,829 --> 00:12:40,339
have to be determined before the

225
00:12:47,919 --> 00:12:44,839
material is chosen both the high and the

226
00:12:50,290 --> 00:12:47,929
low to make sure that the materials are

227
00:12:52,809 --> 00:12:50,300
compatible in the entire range and then

228
00:12:54,910 --> 00:12:52,819
the type of loading static or fatigue

229
00:13:01,509 --> 00:12:54,920
loading is also a factor in the material

230
00:13:05,739 --> 00:13:01,519
selection now as far as availability and

231
00:13:07,509 --> 00:13:05,749
materials the carbon steel fastener

232
00:13:11,230 --> 00:13:07,519
materials of course everybody's familiar

233
00:13:15,939 --> 00:13:11,240
with the 10 10 10 20 that we use around

234
00:13:18,449 --> 00:13:15,949
here and that is just a iron with carbon

235
00:13:24,129 --> 00:13:18,459
in it a few impurities and it's up to

236
00:13:27,220 --> 00:13:24,139
0.28 carbon now that's I'll explain this

237
00:13:30,369 --> 00:13:27,230
further in another chart but the carbon

238
00:13:33,059 --> 00:13:30,379

content is usually called out in points

239
00:13:37,030 --> 00:13:33,069
and it's actually hundreds of a percent

240
00:13:40,780 --> 00:13:37,040
so so this is 0.28 here it's hundreds of

241
00:13:43,490 --> 00:13:40,790
the percent of carbon and you need for

242
00:13:45,440 --> 00:13:43,500
heat treating unless you add

243
00:13:50,810 --> 00:13:45,450
something like boron to the material you

244
00:13:52,580 --> 00:13:50,820
need about 25 points of carbon really to

245
00:13:54,380 --> 00:13:52,590
get it the heat treat properly if you're

246
00:13:56,810 --> 00:13:54,390
going to heat treat a fastener now the

247
00:13:59,840 --> 00:13:56,820
the great files and great eights are in

248
00:14:01,430 --> 00:13:59,850
the 28 to 55 point

249
00:14:04,820 --> 00:14:01,440
carbon range so that their heat

250
00:14:07,670 --> 00:14:04,830
treatable and the the eights of course

251
00:14:09,430 --> 00:14:07,680
have other alloying elements in them in

252
00:14:13,010 --> 00:14:09,440
order that you can bring them up to the

253
00:14:16,580 --> 00:14:13,020
strengths that you want and 4037 is one

254
00:14:17,900 --> 00:14:16,590
of the common materials for grade 8 now

255
00:14:20,900 --> 00:14:17,910
here's something I just wanted to point

256
00:14:22,580 --> 00:14:20,910
out to you that the Charlie Wilson from

257
00:14:24,440 --> 00:14:22,590
the industrial fasteners Institute's

258
00:14:27,710 --> 00:14:24,450
been trying to get this change for years

259
00:14:32,530 --> 00:14:27,720
but it's still in there in jave SAE J

260
00:14:38,290 --> 00:14:32,540
429 spec which is for grade 8 fasteners

261
00:14:43,010 --> 00:14:41,480
manufacturer to furnish these and 1045

262
00:14:46,910 --> 00:14:43,020
plain carbon steel

263
00:14:48,590 --> 00:14:46,920

if the buyer agrees to it well the only

264
00:14:51,170 --> 00:14:48,600
thing is if the buyer doesn't know he's

265
00:14:53,900 --> 00:14:51,180
agreeing to it he can get one that will

266
00:14:55,790 --> 00:14:53,910
not have very good impact resistance and

267
00:14:58,490 --> 00:14:55,800
we had a problem that we were in on one

268
00:15:01,579 --> 00:14:58,500
time with the Army on some Abrams tanks

269
00:15:03,470 --> 00:15:01,589
that when they fired the cannon on him

270
00:15:09,440 --> 00:15:03,480
it broke the bolts on the turret because

271
00:15:16,329 --> 00:15:09,450
it remained out 1045 steel okay moving

272
00:15:19,300 --> 00:15:16,339
on not the ASTM fasteners are used

273
00:15:23,060 --> 00:15:19,310
primarily in the construction industry

274
00:15:27,320 --> 00:15:23,070
so since a lot of you are not familiar

275
00:15:30,140 --> 00:15:27,330
with them and I'm not that familiar with

276
00:15:33,020 --> 00:15:30,150
them either I put in some equivalency

277
00:15:36,670 --> 00:15:33,030
here like the a 307 is a great one in

278
00:15:41,840 --> 00:15:36,680
the sae that we're familiar with and 449

279
00:15:45,410 --> 00:15:41,850
354 and now they the a 193 they're the

280
00:15:49,280 --> 00:15:45,420
the B five six seven sixteen and also

281
00:15:51,980 --> 00:15:49,290
the b 8 stainless steel those are used a

282
00:15:56,300 --> 00:15:51,990
lot for the pipe flanges that we design

283
00:15:57,350 --> 00:15:56,310
around here so so a lot of you are

284
00:16:01,040 --> 00:15:57,360
probably familiar with

285
00:16:06,889 --> 00:16:01,050
them the 320 is an alloy steel for low

286
00:16:09,710 --> 00:16:06,899
temperatures and 325 is a sort of

287
00:16:11,780 --> 00:16:09,720
equivalent to agreed agreed eight in

288
00:16:15,290 --> 00:16:11,790

strength and then the 490 is the highest

289
00:16:20,740 --> 00:16:15,300
strength of the construction type

290
00:16:23,540 --> 00:16:20,750
fasteners now

291
00:16:25,340 --> 00:16:23,550
stainless steel which is a crest you'll

292
00:16:27,560 --> 00:16:25,350
see that designation for it corrosion

293
00:16:31,490 --> 00:16:27,570
resisting steel stainless steel is the

294
00:16:34,970 --> 00:16:31,500
same generic terminology and the super

295
00:16:37,280 --> 00:16:34,980
alloy materials now the 300 series that

296
00:16:39,949 --> 00:16:37,290
we're familiar with around here you get

297
00:16:43,460 --> 00:16:39,959
it up to about 80 ksi because it's not a

298
00:16:44,990 --> 00:16:43,470
heat treatable material so the only way

299
00:16:47,180 --> 00:16:45,000
that you can get the strength opponent

300
00:16:48,769 --> 00:16:47,190
is by work hardening it and informing it

301
00:16:51,920 --> 00:16:48,779
that's about the strength that they get

302
00:16:53,810 --> 00:16:51,930
starting with annealed material eight to

303
00:16:58,360 --> 00:16:53,820
eighty six we use all the time in the

304
00:17:02,180 --> 00:16:58,370
aerospace world up to 160 ksi it is a

305
00:17:05,449 --> 00:17:02,190
very common aerospace material and you

306
00:17:09,220 --> 00:17:05,459
can you can get it in metric by special

307
00:17:13,610 --> 00:17:09,230
order in a 286 the 400 series is

308
00:17:18,169 --> 00:17:13,620
available in limited strengths up to 125

309
00:17:20,780 --> 00:17:18,179
ksi and it's also available in metric

310
00:17:24,079 --> 00:17:20,790
which I will show you further on now the

311
00:17:26,740 --> 00:17:24,089
super alloy is here these are the ones

312
00:17:29,120 --> 00:17:26,750
that you guys come around looking for

313
00:17:33,230 --> 00:17:29,130

when you want something for a

314
00:17:35,000 --> 00:17:33,240
particularly stringent environmental set

315
00:17:37,570 --> 00:17:35,010
of conditions like high temperature

316
00:17:43,760 --> 00:17:37,580
corrosion and so on these are all

317
00:17:45,260 --> 00:17:43,770
stainless --is here in well titanium of

318
00:17:50,990 --> 00:17:45,270
course is very corrosion resistant also

319
00:17:53,120 --> 00:17:51,000
the MP 35 n an MP 159 are made by SPS

320
00:17:56,030 --> 00:17:53,130
they have the patent on the material and

321
00:17:59,950 --> 00:17:56,040
they are super corrosion resistant and

322
00:18:02,659 --> 00:17:59,960
high-strength up to about 220 ksi

323
00:18:05,540 --> 00:18:02,669
inconel at 750 s used for high

324
00:18:09,680 --> 00:18:05,550
temperature and the Haines alloys and

325
00:18:11,400 --> 00:18:09,690
then the 80 to 86 above 160 ksi strength

326
00:18:14,580 --> 00:18:11,410
is a

327
00:18:18,180 --> 00:18:14,590
because in order to get it above about

328
00:18:22,500 --> 00:18:18,190
180 ksi you have to work harden it in

329
00:18:26,010 --> 00:18:22,510
addition to heat treating it now here's

330
00:18:27,690 --> 00:18:26,020
a here's a table of fastener materials I

331
00:18:30,060 --> 00:18:27,700
won't go through each one of these but

332
00:18:31,650 --> 00:18:30,070
one of the things I just wanted to point

333
00:18:37,200 --> 00:18:31,660
out to you and you'll have to go to this

334
00:18:40,890 --> 00:18:37,210
one over here on it is how to figure out

335
00:18:45,720 --> 00:18:40,900
what the designation is now the the aisi

336
00:18:49,169 --> 00:18:45,730
and SAE usually the the numbers are the

337
00:18:52,169 --> 00:18:49,179
same for the steel and in this case here

338
00:18:56,130 --> 00:18:52,179

we have the two as the class of

339
00:19:00,330 --> 00:18:56,140
materials over from over here which is a

340
00:19:02,549 --> 00:19:00,340
nickel steel in this case the three is

341
00:19:05,580 --> 00:19:02,559
the approximate percentage of the main

342
00:19:11,039 --> 00:19:05,590
alloying element which in this case is

343
00:19:16,110 --> 00:19:11,049
is nickel and then the 17 is the carbon

344
00:19:16,950 --> 00:19:16,120
content so this is a low carbon alloy

345
00:19:19,860 --> 00:19:16,960
steel

346
00:19:22,169 --> 00:19:19,870
2317 that has no special significance

347
00:19:26,070 --> 00:19:22,179
other than the fact that it's used to

348
00:19:29,430 --> 00:19:26,080
just illustrate the system now for the

349
00:19:32,970 --> 00:19:29,440
nickel chromium steels and molybdenum

350
00:19:35,730 --> 00:19:32,980
steels and so on here are the ones that

351
00:19:40,289 --> 00:19:35,740
are used mostly for fasteners in alloy

352
00:19:45,720 --> 00:19:40,299
steels the 4000 series you have 40 37 41

353
00:19:52,530 --> 00:19:45,730
40 43 40 that type of thing that is that

354
00:19:56,430 --> 00:19:54,930
now on chemical compositions I guess I

355
00:20:00,660 --> 00:19:56,440
better stay with this one over here for

356
00:20:03,720 --> 00:20:00,670
that also here you see here the the

357
00:20:05,970 --> 00:20:03,730
ordinary hardware store of varieties and

358
00:20:10,020 --> 00:20:05,980
you notice that all of these other

359
00:20:11,910 --> 00:20:10,030
elements are not listed one of the

360
00:20:15,270 --> 00:20:11,920
things you can run into if you if you're

361
00:20:17,730 --> 00:20:15,280
having a real problem sometimes you can

362
00:20:19,590 --> 00:20:17,740
get some of these steels that have

363
00:20:21,300 --> 00:20:19,600

things in them that you don't want the

364
00:20:23,370 --> 00:20:21,310
guy was pointing this out to me from

365
00:20:25,230 --> 00:20:23,380
Lincoln Electric that in welding they're

366
00:20:27,960 --> 00:20:25,240
running into that because a lot of Steel

367
00:20:30,630 --> 00:20:27,970
is made out of scrap so the scrap has

368
00:20:32,190 --> 00:20:30,640
most anything yet so they're getting a

369
00:20:34,620 --> 00:20:32,200
lot of impurities that they don't want

370
00:20:36,570 --> 00:20:34,630
in it and then then you get down here

371
00:20:38,790 --> 00:20:36,580
the standard alloy is the stainless

372
00:20:41,850 --> 00:20:38,800
steels one of the ones that I wanted to

373
00:20:46,310 --> 00:20:41,860
call to your attention on that is the in

374
00:20:49,100 --> 00:20:46,320
the 300 series stainless steel down here

375
00:20:52,740 --> 00:20:49,110
one of the ones that they left out here

376
00:20:57,330 --> 00:20:52,750
was the the L designations the

377
00:20:59,880 --> 00:20:57,340
low-carbon because a lot of the times

378
00:21:03,960 --> 00:20:59,890
you want to minimize the amount of

379
00:21:05,580 --> 00:21:03,970
carbon in it so you use a 304 L or 316 L

380
00:21:07,380 --> 00:21:05,590
or something like that and they did not

381
00:21:09,780 --> 00:21:07,390
put that one in that table so you might

382
00:21:16,280 --> 00:21:09,790
want to just flag it alright moving on

383
00:21:21,810 --> 00:21:16,290
now to operating temperatures here I

384
00:21:26,430 --> 00:21:21,820
have grouped this in categories and so

385
00:21:28,610 --> 00:21:26,440
the minus 65 and below that's your

386
00:21:31,410 --> 00:21:28,620
cryogenic temperatures now of course

387
00:21:33,620 --> 00:21:31,420
those of you who have been around long

388
00:21:38,490 --> 00:21:33,630

enough remember the Atlas and centaur

389
00:21:42,210 --> 00:21:38,500
and curse their liquid hydrogen fueled

390
00:21:47,030 --> 00:21:42,220
so the temperatures are running on that

391
00:21:53,720 --> 00:21:47,040
type of a vehicle or anywhere from about

392
00:21:57,180 --> 00:21:53,730
300 - 300 to minus 423 so you cannot use

393
00:22:02,820 --> 00:21:57,190
carbon steels at those temperatures

394
00:22:04,680 --> 00:22:02,830
because they will crack like glass even

395
00:22:07,010 --> 00:22:04,690
some of the stainless steels will go

396
00:22:12,810 --> 00:22:07,020
below about

397
00:22:18,540 --> 00:22:12,820
- 150 aluminum is good down to those

398
00:22:23,480 --> 00:22:18,550
temperatures then you go to the - 65 -

399
00:22:26,820 --> 00:22:23,490
450 which is a ordinary range for most

400
00:22:31,650 --> 00:22:26,830
engineering designs carbon steels are

401
00:22:33,120 --> 00:22:31,660
okay and stainless steels are okay but

402
00:22:35,340 --> 00:22:33,130
then you get into the business of

403
00:22:37,260 --> 00:22:35,350
needing corrosion protection for the

404
00:22:38,970 --> 00:22:37,270
carbon steel with the various types of

405
00:22:41,670 --> 00:22:38,980
plating like the Sanker cadmium or

406
00:22:44,310 --> 00:22:41,680
phosphate or black oxide or whatever and

407
00:22:51,180 --> 00:22:44,320
those will be covered of course later on

408
00:22:54,720 --> 00:22:51,190
in the platings encoding section now for

409
00:22:54,720 --> 00:22:54,730
the 450 and above

410
00:22:59,880 --> 00:22:56,670
believe it or not you can use unplayed

411
00:23:01,470 --> 00:22:59,890
carbon steel up to about 700 degrees

412
00:23:05,760 --> 00:23:01,480
because the only thing you're looking at

413
00:23:07,710 --> 00:23:05,770

there is how much does the allowable

414
00:23:10,890 --> 00:23:07,720
drop on it for the temperature so if you

415
00:23:13,740 --> 00:23:10,900
go in one of the books like mill

416
00:23:17,160 --> 00:23:13,750
handbook five you can find the

417
00:23:19,260 --> 00:23:17,170
temperature curves for carbon steels and

418
00:23:21,840 --> 00:23:19,270
you find it use it but to see the reason

419
00:23:26,420 --> 00:23:21,850
I'm saying unplayed 'add is that an

420
00:23:28,470 --> 00:23:26,430
awful lot of the platings for Steel's

421
00:23:31,650 --> 00:23:28,480
burn up before you get to that

422
00:23:33,870 --> 00:23:31,660
temperature so these are some some of

423
00:23:37,260 --> 00:23:33,880
the ones that don't hurt you at least

424
00:23:38,730 --> 00:23:37,270
now and I'm just giving these because of

425
00:23:39,990 --> 00:23:38,740
their temperature range rather than the

426
00:23:42,360 --> 00:23:40,000
fact that you'd normally would not

427
00:23:45,420 --> 00:23:42,370
silver to plate a carbon steel but you

428
00:23:48,530 --> 00:23:45,430
do silver plate stainless steel but

429
00:23:54,110 --> 00:23:48,540
silver nickel chromium plating and

430
00:23:58,290 --> 00:23:54,120
chromium plating is used on some

431
00:24:01,800 --> 00:23:58,300
high-strength fasteners for aircraft

432
00:24:03,600 --> 00:24:01,810
landing gear that type of thing the

433
00:24:06,470 --> 00:24:03,610
black oxide coating that you're all

434
00:24:09,980 --> 00:24:06,480
familiar with from your hardware store

435
00:24:13,860 --> 00:24:09,990
bolts looks good and all that but it

436
00:24:16,680 --> 00:24:13,870
burns off then you have diffused nickel

437
00:24:18,420 --> 00:24:16,690
cadmium which is a special one that will

438
00:24:19,230 --> 00:24:18,430

be covered later and then of course you

439
00:24:28,820 --> 00:24:19,240
use the stain

440
00:24:37,080 --> 00:24:32,430
now we although we have a corrosion

441
00:24:37,740 --> 00:24:37,090
section I elected to put the oh sorry

442
00:24:40,799 --> 00:24:37,750
about that

443
00:24:44,549 --> 00:24:40,809
here's here's the table of summary of

444
00:24:46,290 --> 00:24:44,559
fastener materials and you can't read

445
00:24:49,140 --> 00:24:46,300
this one so I'll go over to this one one

446
00:24:52,230 --> 00:24:49,150
of the things that I wanted to point out

447
00:24:56,880 --> 00:24:52,240
to you here is that if you look at the

448
00:25:01,740 --> 00:24:56,890
useful design temperature on these you

449
00:25:06,060 --> 00:25:01,750
find that a 286 is one of the best - for

450
00:25:08,520 --> 00:25:06,070
23 to 1,200 but if you get down through

451
00:25:13,260 --> 00:25:08,530
all of these and you find that this

452
00:25:16,490 --> 00:25:13,270
Hanes 230 at the bottom is the only one

453
00:25:20,340 --> 00:25:16,500
that will carry you up to 1,800 degrees

454
00:25:22,799 --> 00:25:20,350
now the significance of this is that

455
00:25:24,780 --> 00:25:22,809
we've gone through on the NASA program

456
00:25:28,919 --> 00:25:24,790
the national air space plane and

457
00:25:32,190 --> 00:25:28,929
developing all of these super duper

458
00:25:34,650 --> 00:25:32,200
materials to build airplanes out of but

459
00:25:36,660 --> 00:25:34,660
we never did anything on developing

460
00:25:42,930 --> 00:25:36,670
fasteners to put them together because

461
00:25:44,669 --> 00:25:42,940
the regular metal fasteners there's what

462
00:25:50,820 --> 00:25:44,679
they the only thing they have to put

463
00:25:52,980 --> 00:25:50,830

them together okay moving along now into

464
00:25:57,350 --> 00:25:52,990
the galvanic corrosion and stress

465
00:26:01,470 --> 00:25:57,360
corrosion area galvanic corrosion is

466
00:26:05,790 --> 00:26:01,480
something that we're all familiar with

467
00:26:09,630 --> 00:26:05,800
although we may not use that title for

468
00:26:13,430 --> 00:26:09,640
it if you get a scratch on the chromium

469
00:26:15,570 --> 00:26:13,440
plating on your car it will rust faster

470
00:26:17,580 --> 00:26:15,580
that it would if it didn't have any

471
00:26:21,960 --> 00:26:17,590
plating on it because you have a very

472
00:26:27,799 --> 00:26:21,970
small anode in a large cathode being the

473
00:26:30,510 --> 00:26:27,809
rest of the surface so the anode is

474
00:26:33,450 --> 00:26:30,520
deposited on the cathode which means

475
00:26:37,560 --> 00:26:33,460
that it rusts away so rusting is a

476
00:26:40,740 --> 00:26:37,570
galvanic corrosion and later on we have

477
00:26:42,140 --> 00:26:40,750
a table on the galvanic series that will

478
00:26:47,090 --> 00:26:42,150
give you

479
00:26:48,920 --> 00:26:47,100
the location in the table of these and

480
00:26:52,160 --> 00:26:48,930
the farther apart they are in the table

481
00:26:59,480 --> 00:26:52,170
the bigger galvanic corrosion cell you

482
00:27:01,670 --> 00:26:59,490
developed between the two of them and of

483
00:27:03,440 --> 00:27:01,680
course cadmium and zinc are adjacent to

484
00:27:05,720 --> 00:27:03,450
the aluminum in that table which makes

485
00:27:10,670 --> 00:27:05,730
them compatible as coatings for steel

486
00:27:12,710 --> 00:27:10,680
fasteners used in aluminum then and to

487
00:27:15,520 --> 00:27:12,720
further protect mating surfaces from

488
00:27:20,390 --> 00:27:15,530

galvanic corrosion you particularly

489
00:27:23,150 --> 00:27:20,400
where you're putting in rivets and you

490
00:27:27,530 --> 00:27:23,160
drill you pilot drill one piece and and

491
00:27:29,690 --> 00:27:27,540
then drill it through you have raw raw

492
00:27:32,600 --> 00:27:29,700
surfaces that are not plated with

493
00:27:37,420 --> 00:27:32,610
anything so you either use a zinc

494
00:27:42,800 --> 00:27:37,430
chromate paste or there's a mill 8802

495
00:27:50,180 --> 00:27:42,810
sealer that will deter galvanic

496
00:27:52,340 --> 00:27:50,190
corrosion now here is the table or the

497
00:27:54,680 --> 00:27:52,350
galvanic series and this is something

498
00:27:58,730 --> 00:27:54,690
you can find I think marks handbook and

499
00:28:00,530 --> 00:27:58,740
various places have it and one of the

500
00:28:04,790 --> 00:28:00,540
things that I wanted to point out in

501
00:28:08,870 --> 00:28:04,800
this is that if you look at cadmium over

502
00:28:12,350 --> 00:28:08,880
here see it is right in the aluminum's

503
00:28:15,770 --> 00:28:12,360
also zinc is there so if you use a

504
00:28:17,840 --> 00:28:15,780
cadmium plated fastener and aluminum you

505
00:28:22,430 --> 00:28:17,850
will get less galvanic corrosion than

506
00:28:28,010 --> 00:28:22,440
you would say if you used a one of these

507
00:28:30,160 --> 00:28:28,020
down here like a brass or or copper

508
00:28:33,230 --> 00:28:30,170
inconel or something something like that

509
00:28:36,500 --> 00:28:33,240
now notice that there are two different

510
00:28:41,620 --> 00:28:36,510
designations for the stainless steel

511
00:28:44,420 --> 00:28:41,630
that have active and passive normally

512
00:28:48,350 --> 00:28:44,430
stainless steels are passivated which

513
00:28:52,880 --> 00:28:48,360

they're treated with an acid dip to

514
00:28:54,920 --> 00:28:52,890
remove the any kind of scale they had on

515
00:28:57,740 --> 00:28:54,930
them from processing

516
00:28:59,750 --> 00:28:57,750
and to form a protective oxide on the

517
00:29:03,890 --> 00:28:59,760
surface the passivation of Steel

518
00:29:07,610 --> 00:29:03,900
corresponds to anodizing of aluminum so

519
00:29:10,150 --> 00:29:07,620
that's why that they have it shown

520
00:29:14,270 --> 00:29:10,160
differently here passive and active

521
00:29:17,450 --> 00:29:14,280
because the the passive is much less

522
00:29:20,360 --> 00:29:17,460
corrosion a much more corrosion

523
00:29:22,250 --> 00:29:20,370
resistant okay now going to stress

524
00:29:26,360 --> 00:29:22,260
corrosion that is something that we're

525
00:29:30,050 --> 00:29:26,370
all familiar with in a sense but there's

526
00:29:32,660 --> 00:29:30,060
not much available in textbooks on it

527
00:29:37,280 --> 00:29:32,670
because it the the study of it is a

528
00:29:39,320 --> 00:29:37,290
fairly recent thing now stress corrosion

529
00:29:40,910 --> 00:29:39,330
of course occurs when our sensitive

530
00:29:42,590 --> 00:29:40,920
material is loaded in tension in a

531
00:29:45,140 --> 00:29:42,600
corrosive environment now that sounds

532
00:29:47,690 --> 00:29:45,150
pretty easy and what happens the surface

533
00:29:50,450 --> 00:29:47,700
develops pits or cracks from exposure

534
00:29:53,750 --> 00:29:50,460
and this of course gives you stress

535
00:29:59,360 --> 00:29:53,760
risers which will cause the component to

536
00:30:03,850 --> 00:29:59,370
fail at as little as twenty percent of

537
00:30:06,650 --> 00:30:03,860
us calculated load capacity now the

538
00:30:08,840 --> 00:30:06,660

thing about it one of the reasons why I

539
00:30:11,300 --> 00:30:08,850
don't propose using the super high

540
00:30:14,270 --> 00:30:11,310
strength alloy steel fasteners if you

541
00:30:17,030 --> 00:30:14,280
can avoid it is the higher the strength

542
00:30:22,550 --> 00:30:17,040
the more sensitive it is to stress

543
00:30:27,350 --> 00:30:22,560
corrosion so so you try to steer clear

544
00:30:30,560 --> 00:30:27,360
of using super high strength fasteners

545
00:30:34,250 --> 00:30:30,570
in alloy steel for that reason the

546
00:30:36,500 --> 00:30:34,260
stainless steels most of them are not

547
00:30:38,840 --> 00:30:36,510
stress corrosion susceptible other than

548
00:30:41,810 --> 00:30:38,850
the precipitation hardening 17:4 and

549
00:30:43,790 --> 00:30:41,820
17-7 so you ought to look at that before

550
00:30:48,770 --> 00:30:43,800
you select the fasteners that you're

551
00:30:53,200 --> 00:30:48,780
going to use here's another one that you

552
00:30:57,490 --> 00:30:53,210
can run into although it's it's not a

553
00:31:01,820 --> 00:30:57,500
that common as decarburization when you

554
00:31:04,160 --> 00:31:01,830
heat treat a carbon steel you can

555
00:31:07,730 --> 00:31:04,170
actually precipitate carbon out on the

556
00:31:08,590 --> 00:31:07,740
surface and i would compare this to like

557
00:31:10,419 --> 00:31:08,600
charred whew

558
00:31:13,480 --> 00:31:10,429
or something like that you know charred

559
00:31:14,950 --> 00:31:13,490
wood is how it's very soft on the

560
00:31:15,999 --> 00:31:14,960
surface because that this is essentially

561
00:31:19,269 --> 00:31:16,009
what you're getting you're getting a

562
00:31:21,370 --> 00:31:19,279
heavy carbon coat in the outer surface

563
00:31:23,590 --> 00:31:21,380

and of course it's not as strong as the

564
00:31:27,570 --> 00:31:23,600
parent material and on machine parts

565
00:31:30,070 --> 00:31:27,580
they sometimes just machine that off and

566
00:31:31,450 --> 00:31:30,080
and go ahead and and they can use the

567
00:31:33,310 --> 00:31:31,460
part but of course on a fastener you

568
00:31:35,710 --> 00:31:33,320
can't do that so you have to be careful

569
00:31:40,180 --> 00:31:35,720
about decarburization and once again

570
00:31:42,249 --> 00:31:40,190
it's on the strength above 180 ksi now

571
00:31:43,779 --> 00:31:42,259
tempered brittleness is another thing

572
00:31:46,590 --> 00:31:43,789
you can run into on the high strength

573
00:31:50,649 --> 00:31:46,600
fasteners after you have clenched them

574
00:31:53,619 --> 00:31:50,659
then you need to go back and tempura

575
00:31:57,190 --> 00:31:53,629
much means holding a mat at a fairly low

576
00:31:59,740 --> 00:31:57,200
temperature to get the strength that you

577
00:32:04,180 --> 00:31:59,750
need but that also causes the material

578
00:32:10,869 --> 00:32:04,190
to be brittle so carbon steel fasteners

579
00:32:16,990 --> 00:32:10,879
above 190 ksi are a real risk as far as

580
00:32:19,810 --> 00:32:17,000
having brittle failure now you can use

581
00:32:21,070 --> 00:32:19,820
some of the the super alloys and

582
00:32:23,740 --> 00:32:21,080
strengths higher than that but not the

583
00:32:27,249 --> 00:32:23,750
ordinary carbon steel now going to

584
00:32:29,830 --> 00:32:27,259
carbide precipitation this is something

585
00:32:33,190 --> 00:32:29,840
that gets people in trouble a lot where

586
00:32:36,779 --> 00:32:33,200
they don't want a stainless steel to

587
00:32:41,560 --> 00:32:36,789
rest and believe it or not this is

588
00:32:46,210 --> 00:32:41,570

fairly recent least recent for me maybe

589
00:32:47,680 --> 00:32:46,220
for you guys it's ancient but we ran

590
00:32:50,080 --> 00:32:47,690
into this on the Atlas and centaur

591
00:32:51,909 --> 00:32:50,090
programs in which we had joints rusting

592
00:32:54,490 --> 00:32:51,919
down at the Cape with this thing sitting

593
00:32:56,950 --> 00:32:54,500
on the pad and this is stainless steel

594
00:32:58,990 --> 00:32:56,960
it's not supposed to rest but what they

595
00:33:01,659 --> 00:32:59,000
had on that some of these sections were

596
00:33:04,060 --> 00:33:01,669
put together by fusion welding and of

597
00:33:07,810 --> 00:33:04,070
course the only way that you can prevent

598
00:33:14,110 --> 00:33:07,820
it from resting on the 300 these were

599
00:33:15,850 --> 00:33:14,120
301 is to solution treat it after

600
00:33:18,460 --> 00:33:15,860
welding which means you take it up to

601
00:33:20,200 --> 00:33:18,470
about 1800 degrees or something like

602
00:33:21,450 --> 00:33:20,210
that and get the chromium back in

603
00:33:24,000 --> 00:33:21,460
solution

604
00:33:25,590 --> 00:33:24,010
what happens the carbon will combine

605
00:33:27,840 --> 00:33:25,600
with the chromium the form chromium

606
00:33:29,669 --> 00:33:27,850
carbide in the well join and of course

607
00:33:34,019 --> 00:33:29,679
that pulls the chromium out so if you

608
00:33:36,600 --> 00:33:34,029
had your regular 301 is an 18 8 18

609
00:33:38,669 --> 00:33:36,610
chromium 8 nickel so you pull the

610
00:33:43,350 --> 00:33:38,679
chromium out if it falls below about 12

611
00:33:45,750 --> 00:33:43,360
percent the steel rest so this is why

612
00:33:48,480 --> 00:33:45,760
that normally if you're going to have

613
00:33:50,730 --> 00:33:48,490

welded joints you try to use a 300

614
00:33:53,970 --> 00:33:50,740
series with the L designation which is

615
00:33:58,620 --> 00:33:53,980
low carbon and even use a low carbon

616
00:34:01,649 --> 00:33:58,630
well dried or better yet and this is

617
00:34:05,580 --> 00:34:01,659
what we did it mark mariette on the

618
00:34:08,430 --> 00:34:05,590
titan you use 321 stainless because it

619
00:34:12,210 --> 00:34:08,440
has titanium in it the titan or are you

620
00:34:14,550 --> 00:34:12,220
use 347 which has columbium and the

621
00:34:17,099 --> 00:34:14,560
titanium and columbium will combine with

622
00:34:18,750 --> 00:34:17,109
the carbon before the chromium will so

623
00:34:22,109 --> 00:34:18,760
that will leave the chromium in solution

624
00:34:26,520 --> 00:34:22,119
so that you still have the corrosion

625
00:34:28,859 --> 00:34:26,530
resistance so keep that in mind when

626
00:34:30,839 --> 00:34:28,869
selecting fasteners for anything above

627
00:34:34,919 --> 00:34:30,849
about 800 degrees in the stainless steel

628
00:34:39,329 --> 00:34:34,929
to use 321 or 347 now in material

629
00:34:40,649 --> 00:34:39,339
strengths after the temperature and

630
00:34:42,599 --> 00:34:40,659
corrosion requirements have been

631
00:34:46,349 --> 00:34:42,609
determined then you've got a look at the

632
00:34:47,730 --> 00:34:46,359
material strength and once again keep in

633
00:34:49,919 --> 00:34:47,740
mind it's the higher the strength of the

634
00:34:51,300 --> 00:34:49,929
material the more stringent to

635
00:34:55,470 --> 00:34:51,310
manufacturing and quality requirements

636
00:34:58,050 --> 00:34:55,480
become because it's more sensitive to

637
00:35:01,320 --> 00:34:58,060
imperfections if weight is not critical

638
00:35:04,410 --> 00:35:01,330

it's better to use a lot of fasteners of

639
00:35:06,510 --> 00:35:04,420
lower strengths than to use a few high

640
00:35:07,260 --> 00:35:06,520
strength fasteners you use those old

641
00:35:09,810 --> 00:35:07,270
grade eights

642
00:35:12,050 --> 00:35:09,820
if you can use them and you don't have

643
00:35:18,720 --> 00:35:12,060
to worry about weight

644
00:35:21,720 --> 00:35:18,730
now here's metric fasteners and that is

645
00:35:26,750 --> 00:35:21,730
one of the least understood I think

646
00:35:29,400 --> 00:35:26,760
between most design engineers and and

647
00:35:32,430 --> 00:35:29,410
I'll have to admit it's confusing to me

648
00:35:35,280 --> 00:35:32,440
although my my buddy Ben Glenn Dolf who

649
00:35:37,110 --> 00:35:35,290
came from Sweden says that metric is

650
00:35:40,350 --> 00:35:37,120
way of the world he thinks it's great

651
00:35:45,170 --> 00:35:40,360
but I still have trouble with it so go

652
00:35:48,780 --> 00:35:45,180
through some of the peculiarities of

653
00:35:51,000 --> 00:35:48,790
metric fasteners on the property classes

654
00:35:54,000 --> 00:35:51,010
is the way that they specify the

655
00:35:56,580 --> 00:35:54,010
strength and which is a tensile element

656
00:35:59,430 --> 00:35:56,590
in a then yield as a percent of the

657
00:36:01,230 --> 00:35:59,440
ultimate in mega Pascal's and somewhere

658
00:36:03,690 --> 00:36:01,240
here at mega Pascal is one hundred and

659
00:36:08,400 --> 00:36:03,700
forty five point oh four or psi for any

660
00:36:11,160 --> 00:36:08,410
of those you need to convert now the

661
00:36:13,950 --> 00:36:11,170
material is not specified in the

662
00:36:16,260 --> 00:36:13,960
call-out so you have to specify the

663
00:36:18,360 --> 00:36:16,270

material yourself or otherwise you don't

664
00:36:20,670 --> 00:36:18,370
know what you're getting so if you have

665
00:36:24,960 --> 00:36:20,680
like a property class six point eight

666
00:36:26,520 --> 00:36:24,970
it's a carbon steel of some kind with an

667
00:36:29,130 --> 00:36:26,530
ultimate strength of six hundred mega

668
00:36:31,290 --> 00:36:29,140
Pascal's and a yield of eight tenths

669
00:36:35,130 --> 00:36:31,300
times that because that's where the

670
00:36:37,200 --> 00:36:35,140
point eight comes from now for for some

671
00:36:41,790 --> 00:36:37,210
stainless steels they don't use those

672
00:36:44,010 --> 00:36:41,800
rules and so I have a table further down

673
00:36:45,930 --> 00:36:44,020
the line here that shows the peculiar

674
00:36:49,320 --> 00:36:45,940
type stainless steels the way they're

675
00:36:50,790 --> 00:36:49,330
called out the metric system now here's

676
00:36:53,370 --> 00:36:50,800
something I had a little trouble with

677
00:36:56,610 --> 00:36:53,380
getting people to understand around here

678
00:37:06,840 --> 00:36:56,620
because when we had a government decree

679
00:37:11,130 --> 00:37:06,850
to go to the metric fasteners for the CM

680
00:37:13,740 --> 00:37:11,140
one project or for all new projects the

681
00:37:16,890 --> 00:37:13,750
metric aerospace fasteners are not

682
00:37:19,350 --> 00:37:16,900
available in the European market they

683
00:37:23,070 --> 00:37:19,360
use American inch bound fasteners on

684
00:37:25,080 --> 00:37:23,080
their airplanes and I toured the Huck's

685
00:37:26,940 --> 00:37:25,090
rivet plant and to sign a couple years

686
00:37:29,460 --> 00:37:26,950
ago and the chief engineer told me at

687
00:37:31,340 --> 00:37:29,470
the time that it that the a300 people

688
00:37:35,000 --> 00:37:31,350

were their biggest customer at that time

689
00:37:37,950 --> 00:37:35,010
on fasteners because there aren't any

690
00:37:41,700 --> 00:37:37,960
aerospace fasteners available in the

691
00:37:44,910 --> 00:37:41,710
European market so you can get them in

692
00:37:49,080 --> 00:37:44,920
this country on special order and due to

693
00:37:53,810 --> 00:37:49,090
the fact that the property class is

694
00:38:00,750 --> 00:37:53,820
not enough to define the fasteners the

695
00:38:02,970 --> 00:38:00,760
Naas committee and our agency fastener

696
00:38:06,840 --> 00:38:02,980
committee came up with doing it this way

697
00:38:09,570 --> 00:38:06,850
you put out these AIA it's actually na s

698
00:38:11,010 --> 00:38:09,580
specifications that are for metric

699
00:38:13,170 --> 00:38:11,020
fasteners only and this is a very

700
00:38:15,660 --> 00:38:13,180
similar to the m/s or na s sheets that

701
00:38:18,330 --> 00:38:15,670
you see all the time for the inch stuff

702
00:38:20,160 --> 00:38:18,340
but you actually cover everything on

703
00:38:24,740 --> 00:38:20,170
there the heat treat the material

704
00:38:26,850 --> 00:38:24,750
everything and all the dimensions

705
00:38:29,850 --> 00:38:26,860
coatings and so on so that you're

706
00:38:32,400 --> 00:38:29,860
completely covered and you can also

707
00:38:38,400 --> 00:38:32,410
order a metric fasteners from ansi

708
00:38:42,810 --> 00:38:38,410
specifications now here's here's that

709
00:38:49,640 --> 00:38:42,820
kind of a weird duck type table here for

710
00:38:54,690 --> 00:38:49,650
the stainless steel metric fasteners and

711
00:39:00,480 --> 00:38:54,700
these different classes here the a1 a2

712
00:39:03,960 --> 00:39:00,490
a4 and so on and then the 50 70 80 45 60

713
00:39:07,490 --> 00:39:03,970

50 70 80 and so on for some reason or

714
00:39:10,320 --> 00:39:07,500
other you need to add a zero to those in

715
00:39:13,830 --> 00:39:10,330
order to get the actual strength of the

716
00:39:16,560 --> 00:39:13,840
material they made them a class like

717
00:39:20,670 --> 00:39:16,570
that with a that so in other words the

718
00:39:23,940 --> 00:39:20,680
50 here is a 500 mega Pascal ultimate

719
00:39:27,270 --> 00:39:23,950
strength and so so the only way to

720
00:39:28,620 --> 00:39:27,280
identify them is to put them in a table

721
00:39:35,870 --> 00:39:28,630
like that where you can refer back to

722
00:39:39,090 --> 00:39:35,880
them now the next table covers the

723
00:39:41,880 --> 00:39:39,100
different classes and the type of alloys

724
00:39:46,890 --> 00:39:41,890
that are normally used for them the se

725
00:39:50,520 --> 00:39:46,900
here is an S & S II as S is for sulfur

726
00:39:52,740 --> 00:39:50,530
that's an S es for selenium that's

727
00:39:57,690 --> 00:39:52,750
normally added to the 300 series to make

728
00:39:59,910 --> 00:39:57,700
it more machinable so presumably on this

729
00:40:01,020 --> 00:39:59,920
one if you wanted to make your own and

730
00:40:01,470 --> 00:40:01,030
you wanted to cut them out of stainless

731
00:40:02,560 --> 00:40:01,480
steel

732
00:40:05,080 --> 00:40:02,570
then you

733
00:40:09,340 --> 00:40:05,090
use those materials here you have the

734
00:40:12,820 --> 00:40:09,350
304 L and the 321 and 347 which are the

735
00:40:15,910 --> 00:40:12,830
titanium columbium stabilized and then

736
00:40:19,210 --> 00:40:15,920
here the 400 series which are only 25 12

737
00:40:21,310 --> 00:40:19,220
percent chromium and there's another

738
00:40:26,650 --> 00:40:21,320

table further over here that will show

739
00:40:30,070 --> 00:40:26,660
some of that now going to the figure 2 I

740
00:40:33,550 --> 00:40:30,080
will not go through all of this stuff

741
00:40:36,900 --> 00:40:33,560
but this is from the metals handbook it

742
00:40:41,020 --> 00:40:36,910
just gives you a good overall view of

743
00:40:45,940 --> 00:40:41,030
the 300 series and the things that you

744
00:40:48,150 --> 00:40:45,950
do to it to tailor it to your your needs

745
00:40:51,730 --> 00:40:48,160
in fact you probably can't read that

746
00:40:54,250 --> 00:40:51,740
even here at all so it is in your

747
00:40:55,720 --> 00:40:54,260
handout so you can go through it and you

748
00:40:59,530 --> 00:40:55,730
can refer back to it at least when

749
00:41:03,130 --> 00:40:59,540
you're picking a material the figure 3

750
00:41:10,050 --> 00:41:03,140
shows the tailoring of the martensitic

751
00:41:14,070 --> 00:41:10,060
400 series and for those of you who

752
00:41:17,200 --> 00:41:14,080
always wonder what you should what your

753
00:41:19,030 --> 00:41:17,210
Scout knife is made out of it's 440 C

754
00:41:21,700 --> 00:41:19,040
which is down there in the corner

755
00:41:24,280 --> 00:41:21,710
someplace and that's the one that has

756
00:41:28,200 --> 00:41:24,290
the highest except in the upper right

757
00:41:32,130 --> 00:41:28,210
hand corner there has the highest carbon

758
00:41:34,630 --> 00:41:32,140
and a lot of chromium so that it will

759
00:41:38,260 --> 00:41:34,640
give you a high strength you can go up

760
00:41:40,150 --> 00:41:38,270
to about a Rockwell 55 with it C 55 but

761
00:41:46,600 --> 00:41:40,160
it will Nick a lot more readily it's not

762
00:41:49,330 --> 00:41:46,610
as ductile s carbon steel figure-four is

763
00:41:52,290 --> 00:41:49,340

once again this is the standard ferritic

764
00:41:55,210 --> 00:41:52,300
stainless steels of the 430 series and

765
00:41:59,440 --> 00:41:55,220
the different ways of tailoring them so

766
00:42:03,730 --> 00:41:59,450
I won't go through that then we go into

767
00:42:06,640 --> 00:42:03,740
a glossary of terms for materials and

768
00:42:09,910 --> 00:42:06,650
once again there's there's more here

769
00:42:12,310 --> 00:42:09,920
than then I will cover in this

770
00:42:14,440 --> 00:42:12,320
presentation but some of the things I

771
00:42:16,180 --> 00:42:14,450
wanted to call to your attention here

772
00:42:20,680 --> 00:42:16,190
about the the

773
00:42:24,579 --> 00:42:20,690
steals that normally we use the 4000

774
00:42:28,299 --> 00:42:24,589
series then on aluminum's which a cover

775
00:42:31,770 --> 00:42:28,309
here if you want more information on

776
00:42:33,819 --> 00:42:31,780
those you can go to the aluminum

777
00:42:36,370 --> 00:42:33,829
handbook which is put out by the

778
00:42:39,880 --> 00:42:36,380
aluminum association and will give you

779
00:42:43,529 --> 00:42:39,890
more information there the if you look

780
00:42:46,750 --> 00:42:43,539
in the under aluminum alloy is the 2024

781
00:42:52,059 --> 00:42:46,760
2000 series is heat treatable the 3000

782
00:42:54,430 --> 00:42:52,069
series isn't the 5000 series is not heat

783
00:42:57,130 --> 00:42:54,440
treatable but some of them are crows

784
00:42:59,920 --> 00:42:57,140
corrosion stress corrosion sensitive and

785
00:43:02,140 --> 00:42:59,930
the curse the six and seven thousand are

786
00:43:07,990 --> 00:43:02,150
we use all the time they are heat

787
00:43:10,270 --> 00:43:08,000
treatable the down there the leaded

788
00:43:12,579 --> 00:43:10,280

Steel's there are you sometimes I guess

789
00:43:15,160 --> 00:43:12,589
for making one-of-a-kind types crews

790
00:43:19,000 --> 00:43:15,170
they'll add once again is added to steel

791
00:43:21,849 --> 00:43:19,010
to make it easier to machine okay going

792
00:43:25,089 --> 00:43:21,859
over to the next one there

793
00:43:28,180 --> 00:43:25,099
the stainless steels once again there's

794
00:43:33,700 --> 00:43:28,190
there's also a 200 series stainless

795
00:43:36,940 --> 00:43:33,710
steel is very similar than 300 and the

796
00:43:38,500 --> 00:43:36,950
other thing we had a problem down at the

797
00:43:41,559 --> 00:43:38,510
cake one time that they couldn't

798
00:43:44,950 --> 00:43:41,569
determine whether they had used 300 or

799
00:43:47,260 --> 00:43:44,960
400 series fasteners so the way you

800
00:43:52,630 --> 00:43:47,270
check is with a magnet 400 series is

801
00:43:58,109 --> 00:43:52,640
magnetic 300 series is not okay moving

802
00:44:02,500 --> 00:43:58,119
on to the mechanical definitions part

803
00:44:07,120 --> 00:44:02,510
you get into cold working plain carbon

804
00:44:12,970 --> 00:44:07,130
Steel's with cold work can you read that

805
00:44:13,900 --> 00:44:12,980
one over there or not the the plain

806
00:44:16,660 --> 00:44:13,910
carbon Steel's

807
00:44:18,880 --> 00:44:16,670
you can you can cold work them during

808
00:44:21,039 --> 00:44:18,890
deformation in fact one of the reasons

809
00:44:25,059 --> 00:44:21,049
that they start out with the so cold

810
00:44:26,680 --> 00:44:25,069
wire if you will know where somehow

811
00:44:28,359 --> 00:44:26,690
three-quarter inch wire doesn't strike

812
00:44:29,140 --> 00:44:28,369
me as being wire because with the collet

813
00:44:35,249 --> 00:44:29,150

in the

814
00:44:38,319 --> 00:44:35,259
faster plants they run it through and

815
00:44:39,789 --> 00:44:38,329
they but before they run it through they

816
00:44:41,650 --> 00:44:39,799
run it through an annealing furnace to

817
00:44:42,220 --> 00:44:41,660
get it to soft as possible before they

818
00:44:47,380 --> 00:44:42,230
start

819
00:44:50,859 --> 00:44:47,390
and so the fasteners are actually formed

820
00:44:55,150 --> 00:44:50,869
out of this annealed wire and they are

821
00:44:59,559 --> 00:44:55,160
cold worked during the farming in fact

822
00:45:03,759 --> 00:44:59,569
we had I was involved in a quick case on

823
00:45:07,329 --> 00:45:03,769
a product liability thing that the the

824
00:45:09,759 --> 00:45:07,339
nut was actually harder than the bolt in

825
00:45:11,980 --> 00:45:09,769
this case because the nut had been cold

826
00:45:15,099 --> 00:45:11,990
worked more than the boat and it

827
00:45:17,079 --> 00:45:15,109
stripped the threads off the Pope had

828
00:45:20,620 --> 00:45:17,089
caused a chair to fail and a guy got

829
00:45:26,230 --> 00:45:20,630
hurt so just wanted to point those out

830
00:45:28,720 --> 00:45:26,240
to you now going on over to this next

831
00:45:32,980 --> 00:45:28,730
glossary of terms on the process

832
00:45:34,839 --> 00:45:32,990
definitions on one of the things I

833
00:45:37,660 --> 00:45:34,849
wanted to point out there killed steel

834
00:45:39,130 --> 00:45:37,670
is something that is defined here which

835
00:45:41,170 --> 00:45:39,140
normally you don't don't find and that

836
00:45:43,029 --> 00:45:41,180
is important because it it makes the

837
00:45:45,960 --> 00:45:43,039
steel chemically stable so that you

838
00:45:48,700 --> 00:45:45,970

won't get into troubles on it and I

839
00:45:51,099 --> 00:45:48,710
always point out defects that have

840
00:45:54,009 --> 00:45:51,109
happened along the line and one of the

841
00:45:56,079 --> 00:45:54,019
things you remember the cars I believe

842
00:45:59,769 --> 00:45:56,089
it was the Fords and Lincoln's that had

843
00:46:02,079 --> 00:45:59,779
the bumper beam that disintegrated on

844
00:46:04,210 --> 00:46:02,089
them that was because the steel was not

845
00:46:07,989 --> 00:46:04,220
killed killed properly as I understand

846
00:46:11,319 --> 00:46:07,999
it and so you can get disastrous effects

847
00:46:14,620 --> 00:46:11,329
from it the pickling is also the removal

848
00:46:17,470 --> 00:46:14,630
of oxide scale by dipping a steel in a

849
00:46:22,900 --> 00:46:17,480
bath and these are important to have to

850
00:46:24,880 --> 00:46:22,910
prevent corrosion on the material during

851
00:46:31,019 --> 00:46:24,890
the manufacturing process whether it be

852
00:46:32,470 --> 00:46:31,029
fasteners or or general Hardware now the

853
00:46:35,529 --> 00:46:32,480
carburizing

854
00:46:40,630 --> 00:46:35,539
covered so will will not go night

855
00:46:42,910 --> 00:46:40,640
trading and and case hardening actually

856
00:46:45,039 --> 00:46:42,920
in cases like that it's where

857
00:46:46,839 --> 00:46:45,049
you have a material that you want it to

858
00:46:49,539 --> 00:46:46,849
remain ductile because it's some sort of

859
00:46:51,730 --> 00:46:49,549
an impact type thing and so you

860
00:46:54,430 --> 00:46:51,740
case-hardened the surface of it by put

861
00:46:56,410 --> 00:46:54,440
it putting enough carbon on it that you

862
00:47:06,490 --> 00:46:56,420
can harden the surface just to get it

863
00:47:12,280 --> 00:47:06,500

slightly hard okay now moving to

864
00:47:15,400 --> 00:47:12,290
platings and coatings nearly all

865
00:47:17,500 --> 00:47:15,410
commercial fasteners are made of sensors

866
00:47:19,990 --> 00:47:17,510
made of plain carbon or alloy carbon

867
00:47:23,319 --> 00:47:20,000
steel you need some sort of a protection

868
00:47:28,120 --> 00:47:23,329
on them to keep them from rusting so you

869
00:47:30,520 --> 00:47:28,130
can go from puting good old 10w30 oil on

870
00:47:32,500 --> 00:47:30,530
them down all the way to gold plating

871
00:47:35,460 --> 00:47:32,510
now gold plating is not used on

872
00:47:37,809 --> 00:47:35,470
fasteners usually but other than pins on

873
00:47:40,000 --> 00:47:37,819
tubes or something like that in the

874
00:47:41,829 --> 00:47:40,010
electrical field electrical contacts and

875
00:47:43,660 --> 00:47:41,839
so on but if something is small enough

876
00:47:49,690 --> 00:47:43,670
gold plating does not become that

877
00:47:52,420 --> 00:47:49,700
expensive to coat it but usually we go

878
00:47:55,210 --> 00:47:52,430
with something that is less expensive so

879
00:47:57,309 --> 00:47:55,220
but what you're looking for is a coating

880
00:48:00,490 --> 00:47:57,319
that will give you the protection at the

881
00:48:03,640 --> 00:48:00,500
lowest cost so the other thing is with

882
00:48:08,859 --> 00:48:03,650
fasteners you got to have a thin coating

883
00:48:11,620 --> 00:48:08,869
because the fastener threads have to be

884
00:48:15,609 --> 00:48:11,630
within tolerance after the coating which

885
00:48:17,470 --> 00:48:15,619
is important now I know that if you get

886
00:48:20,859 --> 00:48:17,480
nails or something like that

887
00:48:23,260 --> 00:48:20,869
Ron Roman Chuck drives nails all the

888
00:48:25,180 --> 00:48:23,270

time they've been galvanized and that's

889
00:48:28,030 --> 00:48:25,190
a dipping process but it's not used on

890
00:48:33,150 --> 00:48:28,040
normally on threaded fasteners now on on

891
00:48:37,359 --> 00:48:33,160
temperature limitations the coating is

892
00:48:41,770 --> 00:48:37,369
more likely to set the temperature limit

893
00:48:44,680 --> 00:48:41,780
in the fastener material itself and some

894
00:48:46,809 --> 00:48:44,690
coatings can be a disaster when they

895
00:48:49,990 --> 00:48:46,819
decompose like cadmium you get hydrogen

896
00:48:52,990 --> 00:48:50,000
embrittlement from a decomposition of

897
00:48:55,359 --> 00:48:53,000
cadmium and others like the good old

898
00:48:59,020 --> 00:48:55,369
familiar black oxide baked off without

899
00:49:08,660 --> 00:49:04,190
now cadmium plating is although people

900
00:49:12,410 --> 00:49:08,670
say that it is going away because of

901
00:49:16,160 --> 00:49:12,420
environmental problems that's really not

902
00:49:19,670 --> 00:49:16,170
true in fact when I talk to a guy at

903
00:49:22,580 --> 00:49:19,680
Boeing about their development of

904
00:49:23,930 --> 00:49:22,590
replacements for cadmium he said as far

905
00:49:25,400 --> 00:49:23,940
as we're concerned there isn't a

906
00:49:28,040 --> 00:49:25,410
replacement for cadmium we're going to

907
00:49:32,630 --> 00:49:28,050
go ahead using it so it's just the idea

908
00:49:36,800 --> 00:49:32,640
that you have to control the process in

909
00:49:42,500 --> 00:49:36,810
order to keep a PA off your back but it

910
00:49:46,640 --> 00:49:42,510
can used for electro depositing alloy

911
00:49:49,760 --> 00:49:46,650
steel up to 190 ksi if you get above 190

912
00:49:51,590 --> 00:49:49,770
ksi then you can't prevent hydrogen

913
00:49:53,480 --> 00:49:51,600

embrittlement and you have to go to a

914
00:49:55,880 --> 00:49:53,490
vacuum deposit which runs the cost way

915
00:50:00,170 --> 00:49:55,890
up now here's something that is

916
00:50:03,190 --> 00:50:00,180
overlooked a lot and causes lots of

917
00:50:06,560 --> 00:50:03,200
problems when parts are cadmium plated

918
00:50:09,290 --> 00:50:06,570
they have to be baked within two hours

919
00:50:11,210 --> 00:50:09,300
after plating and this the reason I said

920
00:50:14,030 --> 00:50:11,220
eight to twenty three hours it depends

921
00:50:16,430 --> 00:50:14,040
on who's baking them or if any baking is

922
00:50:19,130 --> 00:50:16,440
done because some I have heard of cases

923
00:50:22,330 --> 00:50:19,140
in which no baking had always done to

924
00:50:25,070 --> 00:50:22,340
bake the hydrogen out whenever you do a

925
00:50:29,330 --> 00:50:25,080
electroplating process it's done in a

926
00:50:31,700 --> 00:50:29,340
some sort of an aqueous environment so

927
00:50:35,270 --> 00:50:31,710
as you know from charging your battery

928
00:50:39,170 --> 00:50:35,280
you get free hydrogen whenever you put

929
00:50:42,650 --> 00:50:39,180
electrodes in water so you have free

930
00:50:46,070 --> 00:50:42,660
hydrogen ions and of course hydrogen can

931
00:50:49,280 --> 00:50:46,080
go where anything else can't go so you

932
00:50:51,680 --> 00:50:49,290
get hydrogen given off during the

933
00:50:53,600 --> 00:50:51,690
process so unless you bake the material

934
00:50:56,900 --> 00:50:53,610
right after it you're in trouble now

935
00:51:02,290 --> 00:50:56,910
cadmium melts at 610 degrees so it's

936
00:51:07,750 --> 00:51:05,470
now the advantages of cadmium it's good

937
00:51:11,500 --> 00:51:07,760
salt spray resistance so it's very good

938
00:51:13,630 --> 00:51:11,510

and marine environment for airplanes

939
00:51:15,700 --> 00:51:13,640
where they're exposed to salt all the

940
00:51:18,700 --> 00:51:15,710
time in the wintertime it's consistent

941
00:51:21,700 --> 00:51:18,710
on the torque friction properties it has

942
00:51:24,160 --> 00:51:21,710
a good Taliban ik corrosion location and

943
00:51:27,580 --> 00:51:24,170
it doesn't decrease the base material

944
00:51:30,190 --> 00:51:27,590
fatigue strength but the disadvantage is

945
00:51:32,740 --> 00:51:30,200
it generates cyanide during the plating

946
00:51:36,010 --> 00:51:32,750
process which is nasty stuff that the

947
00:51:39,880 --> 00:51:36,020
EPA watches very closely and of course I

948
00:51:42,130 --> 00:51:39,890
mentioned the plating and baking has to

949
00:51:44,740 --> 00:51:42,140
be closely controlled and void hydrogen

950
00:51:47,260 --> 00:51:44,750
embrittlement and it causes

951
00:51:49,600 --> 00:51:47,270
embrittlement of titanium it's very

952
00:51:51,550 --> 00:51:49,610
expensive and it has to be vacuum

953
00:51:55,630 --> 00:51:51,560
deposited on high-strength parts to

954
00:51:57,700 --> 00:51:55,640
avoid hydrogen embrittlement so but one

955
00:52:00,330 --> 00:51:57,710
of the other advantages of it that I

956
00:52:03,760 --> 00:52:00,340
didn't list there it does not support

957
00:52:09,250 --> 00:52:03,770
fungus growth whereas a lot of platings

958
00:52:12,070 --> 00:52:09,260
will since cadmium is kind of a toxic

959
00:52:13,780 --> 00:52:12,080
type thing your moles and stuff like

960
00:52:18,400 --> 00:52:13,790
that in a marine environment can't grill

961
00:52:19,300 --> 00:52:18,410
on it now zinc plating zinc is very

962
00:52:22,300 --> 00:52:19,310
common

963
00:52:25,270 --> 00:52:22,310

most of the fasteners that you buy that

964
00:52:28,450 --> 00:52:25,280
are plated or probably zinc plated and

965
00:52:31,990 --> 00:52:28,460
of course hot dip zinc plating is called

966
00:52:37,420 --> 00:52:32,000
galvanizing you get roofing nails that

967
00:52:39,520 --> 00:52:37,430
type of thing our galvanized the roof

968
00:52:41,890 --> 00:52:39,530
that corrugated roof and so on is

969
00:52:43,630 --> 00:52:41,900
galvanized now the zinc plating doesn't

970
00:52:46,000 --> 00:52:43,640
generate the toxic byproducts the

971
00:52:49,300 --> 00:52:46,010
cadmium generates there's a lot cheaper

972
00:52:51,910 --> 00:52:49,310
than cadmium but it will heal itself

973
00:52:55,720 --> 00:52:51,920
over by migrating over scratch there is

974
00:52:58,180 --> 00:52:55,730
if you scratch an area in fact down at

975
00:53:02,500 --> 00:52:58,190
the keep they did a study on how far a

976
00:53:05,770 --> 00:53:02,510
zinc would migrate and it would go over

977
00:53:09,490 --> 00:53:05,780
a scratch about an eighth of inch wide

978
00:53:12,760 --> 00:53:09,500
and go back and and heal it will kind of

979
00:53:16,059 --> 00:53:12,770
heal itself desert extent and it has a

980
00:53:18,579 --> 00:53:16,069
good galvanic location

981
00:53:20,589 --> 00:53:18,589
but it's not as good as cadmium for

982
00:53:22,449 --> 00:53:20,599
corrosion resistance and the Turk

983
00:53:23,620 --> 00:53:22,459
tension friction characteristics in

984
00:53:26,439 --> 00:53:23,630
other words when you're talking up a

985
00:53:28,449 --> 00:53:26,449
fastener you can get such a variation in

986
00:53:31,989 --> 00:53:28,459
the coefficient of friction that you can

987
00:53:35,769 --> 00:53:31,999
get in real trouble on knowing what load

988
00:53:37,660 --> 00:53:35,779

you're putting on it and but it can

989
00:53:39,279 --> 00:53:37,670
adhere here's one of the other bad

990
00:53:41,380 --> 00:53:39,289
things about it it has a useful

991
00:53:43,439 --> 00:53:41,390
temperature limit of only about 250

992
00:53:46,839 --> 00:53:43,449
degrees so you can't use it at all or

993
00:53:48,099 --> 00:53:46,849
your have elevated temperatures and it

994
00:53:50,229 --> 00:53:48,109
can cause hydrogen embrittlement

995
00:53:53,469 --> 00:53:50,239
although it's not a serious a problem as

996
00:53:55,089 --> 00:53:53,479
it is with the cadmium now the phosphate

997
00:53:56,799 --> 00:53:55,099
coatings this is used a lot in the

998
00:54:02,049 --> 00:53:56,809
automotive business because it's cheap

999
00:54:03,789 --> 00:54:02,059
you throw a a cup of phosphate in a

1000
00:54:06,430 --> 00:54:03,799
barrel and put a bunch of fasteners in

1001
00:54:08,949 --> 00:54:06,440
and shake them a few times and you have

1002
00:54:17,229 --> 00:54:08,959
phosphate coated passengers more or less

1003
00:54:20,939 --> 00:54:17,239
and so the mildly protective layer of

1004
00:54:23,439 --> 00:54:20,949
phosphate is formed on the surface and

1005
00:54:26,559 --> 00:54:23,449
there's three different ones or zinc

1006
00:54:28,150 --> 00:54:26,569
iron and manganese and the ones usually

1007
00:54:37,230 --> 00:54:28,160
used for fasteners is the zinc or

1008
00:54:43,450 --> 00:54:40,090
now the advantages of phosphate coatings

1009
00:54:45,300 --> 00:54:43,460
they're cheap you can coat them with oil

1010
00:54:49,150 --> 00:54:45,310
or wax to increase the corrosion

1011
00:54:50,770 --> 00:54:49,160
resistance and the phosphate is a good

1012
00:54:52,840 --> 00:54:50,780
primer for painting so if you're going

1013
00:54:55,600 --> 00:54:52,850

to paint something after you've possibly

1014
00:54:57,990 --> 00:54:55,610
coated it that's great and you don't get

1015
00:54:59,980 --> 00:54:58,000
hydrogen embrittlement from it but

1016
00:55:02,830 --> 00:54:59,990
disadvantage it's not very good in

1017
00:55:04,990 --> 00:55:02,840
corrosion you get in consistent tension

1018
00:55:07,830 --> 00:55:05,000
friction properties which means if you

1019
00:55:13,960 --> 00:55:07,840
are supposed to torque ahead bolt to

1020
00:55:15,250 --> 00:55:13,970
exactly 2,000 pounds tensile load you

1021
00:55:17,550 --> 00:55:15,260
don't know what torque it will take to

1022
00:55:19,810 --> 00:55:17,560
do it if you have different fasteners

1023
00:55:22,840 --> 00:55:19,820
that were in a different location in the

1024
00:55:30,820 --> 00:55:22,850
barrel and they have a limited

1025
00:55:35,680 --> 00:55:30,830
temperature of 225 to 400 degrees now

1026
00:55:37,660 --> 00:55:35,690
nickel plating nickel with or without a

1027
00:55:40,390 --> 00:55:37,670
copper strike is one of the oldest

1028
00:55:44,950 --> 00:55:40,400
methods of preventing corrosion and

1029
00:55:48,400 --> 00:55:44,960
improving the appearance of steel and

1030
00:55:52,110 --> 00:55:48,410
brass it it'll tarnish unless it's

1031
00:55:56,590 --> 00:55:52,120
chromium plated but it has a fairly high

1032
00:55:59,710 --> 00:55:56,600
allowable temperature and good corrosion

1033
00:56:02,770 --> 00:55:59,720
resistance the disadvantage it's more

1034
00:56:04,900 --> 00:56:02,780
expensive than cadmium or zinc that

1035
00:56:07,180 --> 00:56:04,910
requires baking after plating to prevent

1036
00:56:12,300 --> 00:56:07,190
hydrogen embrittlement and it doesn't

1037
00:56:19,090 --> 00:56:15,100
now moving on to chromium plating

1038
00:56:21,340 --> 00:56:19,100

chromium plating of course I thought you

1039
00:56:27,250 --> 00:56:21,350
all know is used for automotive and

1040
00:56:29,770 --> 00:56:27,260
appliance decoration and very thin coats

1041
00:56:33,690 --> 00:56:29,780
but it can be used for fasteners as I

1042
00:56:39,220 --> 00:56:33,700
mentioned earlier it's used for coating

1043
00:56:41,740 --> 00:56:39,230
fasteners for landing gear this type of

1044
00:56:46,390 --> 00:56:41,750
thing where you require the super

1045
00:56:52,930 --> 00:56:46,400
high-strength fasteners or components

1046
00:56:55,240 --> 00:56:52,940
and so you can't use something else that

1047
00:56:59,820 --> 00:56:55,250
would be like in a stainless steel so

1048
00:57:03,130 --> 00:56:59,830
you go to the the very high strength

1049
00:57:07,480 --> 00:57:03,140
carbon steel alloy steel and then you

1050
00:57:09,340 --> 00:57:07,490
chrome plate it but you've got to put to

1051
00:57:11,800 --> 00:57:09,350
get a good chrome plate you got to put a

1052
00:57:13,540 --> 00:57:11,810
copper strike on first and then a nickel

1053
00:57:17,290 --> 00:57:13,550
over that and then the chromium goes

1054
00:57:21,610 --> 00:57:17,300
over the two of them otherwise the

1055
00:57:25,210 --> 00:57:21,620
chromium is porous to a certain extent

1056
00:57:28,570 --> 00:57:25,220
so if you have unless you have something

1057
00:57:30,400 --> 00:57:28,580
under it to help it it doesn't work out

1058
00:57:34,480 --> 00:57:30,410
too well or you have to go with a fairly

1059
00:57:37,180 --> 00:57:34,490
thick coat so and it can be used up to

1060
00:57:37,930 --> 00:57:37,190
about 1,200 degrees and of course it

1061
00:57:40,300 --> 00:57:37,940
looks good

1062
00:57:42,250 --> 00:57:40,310
but your the thing you run into it's

1063
00:57:45,010 --> 00:57:42,260

just expensive a stainless steel so you

1064
00:57:46,870 --> 00:57:45,020
only use it for the special cases and it

1065
00:57:49,450 --> 00:57:46,880
requires very stringent quality control

1066
00:57:51,910 --> 00:57:49,460
because you know what a disaster it

1067
00:57:55,630 --> 00:57:51,920
would be if you get a hole through it

1068
00:57:58,090 --> 00:57:55,640
and the salt gets in it then you have

1069
00:57:59,650 --> 00:57:58,100
something rusting very fast and of

1070
00:58:01,360 --> 00:57:59,660
course you have to do the baking to

1071
00:58:04,770 --> 00:58:01,370
prevent hydrogen embrittlement with that

1072
00:58:08,400 --> 00:58:04,780
same as you do with the cadmium plating

1073
00:58:10,960 --> 00:58:08,410
now here's the ion vapor deposited

1074
00:58:13,720 --> 00:58:10,970
aluminum plating this is a special one

1075
00:58:16,150 --> 00:58:13,730
that was developed I believe yeah by

1076
00:58:19,780 --> 00:58:16,160
McDonnell Douglas for coating of

1077
00:58:23,010 --> 00:58:19,790
aircraft parts and it was going to be

1078
00:58:25,930 --> 00:58:23,020
used as an alternate to cadmium plating

1079
00:58:29,110 --> 00:58:25,940
well it doesn't give you hydrogen

1080
00:58:31,210 --> 00:58:29,120
embrittlement and it insulates to deter

1081
00:58:32,470 --> 00:58:31,220
the galvanic corrosion and can be used

1082
00:58:36,370 --> 00:58:32,480
up to nine hundred and twenty-five

1083
00:58:39,760 --> 00:58:36,380
degrees and is and doesn't give off any

1084
00:58:42,700 --> 00:58:39,770
toxic byproducts but it's expensive and

1085
00:58:45,700 --> 00:58:42,710
has to be done in a vacuum so you can

1086
00:58:48,460 --> 00:58:45,710
send it out to Joe Dokes plating outfit

1087
00:58:51,430 --> 00:58:48,470
to get it done and it's not as good as

1088
00:58:56,040 --> 00:58:51,440

cadmium in a salt spray test so it has

1089
00:58:59,260 --> 00:58:56,050
not had that wide usage that I know of

1090
00:59:00,040 --> 00:58:59,270
diffused nickel cadmium is another one

1091
00:59:03,630 --> 00:59:00,050
that was the

1092
00:59:08,200 --> 00:59:03,640
by the aerospace industry as a

1093
00:59:10,750 --> 00:59:08,210
high-temperature cadmium plating and you

1094
00:59:13,780 --> 00:59:10,760
put a nickel coating on first and then

1095
00:59:16,780 --> 00:59:13,790
put capping on over it and bake it for

1096
00:59:18,730 --> 00:59:16,790
one hour at 645 degrees now the

1097
00:59:21,760 --> 00:59:18,740
advantage you get up to about a thousand

1098
00:59:24,250 --> 00:59:21,770
degrees exposure temperature which is

1099
00:59:26,500 --> 00:59:24,260
good versus 450 for plane cadmium

1100
00:59:30,000 --> 00:59:26,510
plating but once again it's expensive

1101
00:59:33,090 --> 00:59:30,010
you you have to have extremely close

1102
00:59:35,800 --> 00:59:33,100
process controls and the nickel plate

1103
00:59:37,930 --> 00:59:35,810
has to cover the fastener at all times

1104
00:59:40,450 --> 00:59:37,940
to avoid cadmium damage to the fastener

1105
00:59:50,250 --> 00:59:40,460
material so and it's not recommended for

1106
00:59:53,680 --> 00:59:50,260
parts above 200 KS is strength okay

1107
00:59:55,990 --> 00:59:53,690
silver plating silver plating is used to

1108
00:59:58,270 --> 00:59:56,000
prevent corrosion and as a solid

1109
01:00:01,330 --> 00:59:58,280
lubricant for fasteners for instance

1110
01:00:05,050 --> 01:00:01,340
it's customary to silver plate a

1111
01:00:09,310 --> 01:00:05,060
stainless steel nut for a stainless

1112
01:00:13,540 --> 01:00:09,320
steel bolt in order to prevent galling

1113
01:00:15,490 --> 01:00:13,550

and serve as a lubricant now silver

1114
01:00:20,800 --> 01:00:15,500
plating can be used up to about 1600

1115
01:00:25,420 --> 01:00:20,810
degrees and its disadvantages though

1116
01:00:27,359 --> 01:00:25,430
it's expensive it tarnishes and it

1117
01:00:30,400 --> 01:00:27,369
shouldn't be used in direct contact with

1118
01:00:35,109 --> 01:00:30,410
titanium so its primary use in their

1119
01:00:37,810 --> 01:00:35,119
aerospace field is just to coat

1120
01:00:40,290 --> 01:00:37,820
stainless steel parts on stainless steel

1121
01:00:46,290 --> 01:00:40,300
to prevent the thing from galling

1122
01:00:49,390 --> 01:00:46,300
okay we will take a break now and resume