Fastener Torque

Torque Definitions (Cont'd)

Free Running Torque (No Load Torque) - Torque required to overcome kinetic friction between mating threads. It can be measured in either the loosening or tightening direction. Free running torque does not include torque required to overcome a self-locking feature or to increase or decrease the axial load in the fastener. Under normal conditions, free running torque is negligible.

1
00:01:12,040 --> 00:01:08,860
okay all right we'll continue with tap

2
00:01:14,200 --> 00:01:12,050
threads and in case you're wondering

3
00:01:16,630 --> 00:01:14,210
what page you were you're on those of

4
00:01:23,230 --> 00:01:16,640
you who have joined us for this session

5
00:01:28,090 --> 00:01:23,240
this page should be page 926 and now

6
00:01:31,719 --> 00:01:28,100
tapping as done with either by hand or

7
00:01:35,320 --> 00:01:31,729
by machine and the bulk of the metal

8
00:01:37,210 --> 00:01:35,330
those is taken out with the tap drill of

9
00:01:39,010 --> 00:01:37,220
course which has a diameter equal to or

10
00:01:42,280 --> 00:01:39,020
slightly greater than the root diameter

11
00:01:45,400 --> 00:01:42,290
the thread and of course that we covered

12
00:01:51,550 --> 00:01:45,410
the number of tempered threads and so on

13
00:01:53,109 --> 00:01:51,560

and then the bottom tap one of the

14
00:01:56,890 --> 00:01:53,119
things I wanted to mention there is that

15
00:01:59,109 --> 00:01:56,900
I guess in some cases you have to even

16
00:02:01,240 --> 00:01:59,119
take a they have the hundred and twenty

17
00:02:02,859 --> 00:02:01,250
degree cone and I think on the bottom of

18
00:02:04,480 --> 00:02:02,869
them and you have to grind it off I

19
00:02:06,160 --> 00:02:04,490
think sometimes if you really want to

20
00:02:11,130 --> 00:02:06,170
get all the way down to the bottom of

21
00:02:14,170 --> 00:02:11,140
the hole now here's Acme threads and

22
00:02:15,550 --> 00:02:14,180
those are kind of an oddball type but

23
00:02:18,520 --> 00:02:15,560
nevertheless they've been around since

24
00:02:22,390 --> 00:02:18,530
the 1800s and they're used for

25
00:02:26,250 --> 00:02:22,400
transmitting power unlike on jacks and

26
00:02:29,530 --> 00:02:26,260
reversing motions on machinery in fact

27
00:02:32,680 --> 00:02:29,540
those of you who've ever leveled a house

28
00:02:35,860 --> 00:02:32,690
or something with a house jack they are

29
00:02:39,759 --> 00:02:35,870
Acme threads they're kind of a square

30
00:02:43,660 --> 00:02:39,769
cut tape thread and scissors Jack's

31
00:02:47,020 --> 00:02:43,670
sometimes have Acme threads on them they

32
00:02:49,539 --> 00:02:47,030
have a general-purpose fit class of two

33
00:02:51,539 --> 00:02:49,549
G 3G and 4G with two G being the

34
00:02:54,340 --> 00:02:51,549
sloppiest and four G the tightest and

35
00:02:56,080 --> 00:02:54,350
they have a series of diameters and

36
00:02:58,210 --> 00:02:56,090
threads that are to be used whenever

37
00:03:00,910 --> 00:02:58,220
possible and they call it centralizing

38
00:03:05,020 --> 00:03:00,920

for the tolerances and have the three

39
00:03:07,000 --> 00:03:05,030
three classes and the two see of course

40
00:03:08,650 --> 00:03:07,010
is the the worst and the four C's the

41
00:03:10,590 --> 00:03:08,660
best depending on what you want as far

42
00:03:15,819 --> 00:03:10,600
as backlash or anything like that goes

43
00:03:16,440 --> 00:03:15,829
and the same tolerance designations are

44
00:03:22,979 --> 00:03:16,450
used for both

45
00:03:24,660 --> 00:03:22,989
internal external threads now here they

46
00:03:32,750 --> 00:03:24,670
are as you can see they're kind of a

47
00:03:36,630 --> 00:03:32,760
square type thread very thick stubby and

48
00:03:38,190 --> 00:03:36,640
transmit a lot of power and in this case

49
00:03:39,840 --> 00:03:38,200
they really don't have much of a radius

50
00:03:41,340 --> 00:03:39,850
in the bottom because they make them so

51
00:03:43,259 --> 00:03:41,350
strong if they figure that they'll carry

52
00:03:46,589 --> 00:03:43,269
a carry the load and of course there's

53
00:03:48,870 --> 00:03:46,599
no there's no impact loads normally on

54
00:03:50,880 --> 00:03:48,880
these because it's something that you're

55
00:03:54,600 --> 00:03:50,890
turning so slowly that you don't

56
00:03:56,910 --> 00:03:54,610
generate any impact loading then we go

57
00:03:59,160 --> 00:03:56,920
to stub acne it's about the same thing

58
00:04:04,890 --> 00:03:59,170
as the other one except that it has a

59
00:04:09,150 --> 00:04:04,900
shorter height on the threads and the

60
00:04:12,150 --> 00:04:09,160
seat this is the one I believe no it

61
00:04:14,850 --> 00:04:12,160
isn't either I was thinking one of them

62
00:04:18,390 --> 00:04:14,860
with a English and the Americans have a

63
00:04:24,270 --> 00:04:18,400

different set up on it but they stub

64
00:04:28,500 --> 00:04:24,280
acne is the regular is 0.5 pitch while

65
00:04:31,020 --> 00:04:28,510
the stub is 0.3 and if you turn over you

66
00:04:32,760 --> 00:04:31,030
can see the difference on the next table

67
00:04:37,409 --> 00:04:32,770
you see it really just has shorter

68
00:04:38,940 --> 00:04:37,419
threads on it in in this direction and

69
00:04:40,770 --> 00:04:38,950
of course all the different thread

70
00:04:43,320 --> 00:04:40,780
geometries and everything are on there

71
00:04:45,330 --> 00:04:43,330
and the pitch diameter and all that you

72
00:04:48,659 --> 00:04:45,340
can look up at your own leisure when you

73
00:04:55,230 --> 00:04:48,669
feel that do you need something to help

74
00:04:57,600 --> 00:04:55,240
your insomnia ah buttress threads they

75
00:04:59,310 --> 00:04:57,610
have been around a long time too and

76
00:05:02,090 --> 00:04:59,320
they're kind of special and they're used

77
00:05:05,400 --> 00:05:02,100
where loading is in one direction

78
00:05:08,130 --> 00:05:05,410
typical examples are airplane propeller

79
00:05:11,040 --> 00:05:08,140
hubs columns were hydraulic presses and

80
00:05:13,260 --> 00:05:11,050
breech assemblies of large guns they

81
00:05:15,840 --> 00:05:13,270
have a flat angle on the the loading

82
00:05:18,330 --> 00:05:15,850
side of only 7 degrees from the

83
00:05:22,219 --> 00:05:18,340
perpendicular and in a pressure angle of

84
00:05:26,339 --> 00:05:22,229
45 degrees and this is the one that the

85
00:05:29,320 --> 00:05:26,349
British in the Americans differ on the

86
00:05:35,380 --> 00:05:29,330
height of the threads

87
00:05:39,180 --> 00:05:35,390
point four pitch and 6/10 pitch but with

88
00:05:42,780 --> 00:05:39,190

us prefers the point four and the

89
00:05:45,100 --> 00:05:42,790
British believe the use of the point six

90
00:05:46,680 --> 00:05:45,110
now I'm sorry Americans use the point

91
00:05:52,120 --> 00:05:46,690
six and the British use the point four

92
00:05:54,610 --> 00:05:52,130
but anyway a guy pointed out an example

93
00:05:58,330 --> 00:05:54,620
of these to me here while back that they

94
00:06:01,120 --> 00:05:58,340
had a press in their plant that they had

95
00:06:03,190 --> 00:06:01,130
to fix and he found that it had these

96
00:06:06,610 --> 00:06:03,200
odd ball threads on it called buttress

97
00:06:08,020 --> 00:06:06,620
threads and he knew that I was into

98
00:06:10,270 --> 00:06:08,030
fasteners he said you ever hear a

99
00:06:12,070 --> 00:06:10,280
butters threads down there I've heard of

100
00:06:13,750 --> 00:06:12,080
them they're not very common and you see

101
00:06:15,970 --> 00:06:13,760
there aren't kind of odd here here's

102
00:06:18,340 --> 00:06:15,980
that seven degree angle on the pressure

103
00:06:22,450 --> 00:06:18,350
face of them here now this is this is

104
00:06:27,240 --> 00:06:22,460
two different pictures from a an suspect

105
00:06:31,000 --> 00:06:27,250
I believe one shows threads with a

106
00:06:35,200 --> 00:06:31,010
radius up here the other one shows

107
00:06:38,020 --> 00:06:35,210
threads with no radius and they have

108
00:06:42,070 --> 00:06:38,030
their use and the the thing about this

109
00:06:44,650 --> 00:06:42,080
this guy found out with his press if you

110
00:06:48,940 --> 00:06:44,660
want to fix them these are normally

111
00:06:51,460 --> 00:06:48,950
machined cut on there's no no taps no

112
00:06:55,030 --> 00:06:51,470
dice no nothing for them you have to fix

113
00:06:58,540 --> 00:06:55,040

them yourself drain them in place now if

114
00:07:01,300 --> 00:06:58,550
we go to cross-sectional areas for third

115
00:07:03,160 --> 00:07:01,310
calculation you have different cross

116
00:07:06,640 --> 00:07:03,170
sectional areas for tension and shear

117
00:07:08,620 --> 00:07:06,650
stress calculations if a fastener is

118
00:07:10,390 --> 00:07:08,630
loaded in shear with no threads in the

119
00:07:12,250 --> 00:07:10,400
shear plane of the hole and the full

120
00:07:15,190 --> 00:07:12,260
shank area can be used for the shear

121
00:07:17,530 --> 00:07:15,200
stress calculations for tensile stress

122
00:07:19,210 --> 00:07:17,540
you use a minimum area through the

123
00:07:22,710 --> 00:07:19,220
threaded portion of fastener but it's

124
00:07:25,060 --> 00:07:22,720
it's not a circle with a diameter of

125
00:07:28,810 --> 00:07:25,070
equal to the minor diameter because

126
00:07:30,100 --> 00:07:28,820
since you have a root on one side and

127
00:07:32,440 --> 00:07:30,110
thread on the other side you get

128
00:07:36,070 --> 00:07:32,450
slightly better benefit than that on the

129
00:07:38,080 --> 00:07:36,080
diameter so so you get an effective

130
00:07:41,020 --> 00:07:38,090
diameter this slightly larger and there

131
00:07:42,710 --> 00:07:41,030
is a formula for calculating it there

132
00:07:46,880 --> 00:07:42,720
are a number of formulas for

133
00:07:50,720 --> 00:07:46,890
that goes but here is a common one in

134
00:07:53,000 --> 00:07:50,730
which n is the threads per inch in the

135
00:07:55,490 --> 00:07:53,010
English system and D is the shank

136
00:07:57,290 --> 00:07:55,500
diameter so you have this is your

137
00:07:59,510 --> 00:07:57,300
correction factor here for the fact

138
00:08:02,450 --> 00:07:59,520

you're not using the full diameter of it

139
00:08:04,820 --> 00:08:02,460
and then for metric fasteners you have

140
00:08:07,070 --> 00:08:04,830
this for the correction factor where P

141
00:08:09,110 --> 00:08:07,080
is is the thread pitch in millimeters

142
00:08:12,830 --> 00:08:09,120
and D is the shank diameter in

143
00:08:14,570 --> 00:08:12,840
millimeters so and in the appendices

144
00:08:17,960 --> 00:08:14,580
which you people don't have but we'll be

145
00:08:21,440 --> 00:08:17,970
getting later we have a derivation of

146
00:08:26,720 --> 00:08:21,450
this tension formula for calculating the

147
00:08:28,880 --> 00:08:26,730
cross sectional areas now here's a

148
00:08:32,089 --> 00:08:28,890
little handy-dandy formula for

149
00:08:34,459 --> 00:08:32,099
calculating thread pullout and this is

150
00:08:36,890 --> 00:08:34,469
one that I've never seen in a textbook I

151
00:08:40,790 --> 00:08:36,900
got it from some of the people I worked

152
00:08:43,850 --> 00:08:40,800
with at Martin Marietta it's for

153
00:08:47,810 --> 00:08:43,860
sheering off threads in a hole where

154
00:08:50,810 --> 00:08:47,820
normally when you tap into a hole the

155
00:08:54,380 --> 00:08:50,820
material you're tapping into is weaker

156
00:08:57,710 --> 00:08:54,390
than the fastener so you're concerned

157
00:08:59,840 --> 00:08:57,720
about how long the thread engagement you

158
00:09:04,540 --> 00:08:59,850
have to have keep from pulling the thing

159
00:09:07,760 --> 00:09:04,550
out so this this formula helps you to

160
00:09:10,579 --> 00:09:07,770
conservatively arrive at that you have

161
00:09:14,000 --> 00:09:10,589
pi times a mean diameter and the mean

162
00:09:16,760 --> 00:09:14,010
diameter is usually a pitch diameter and

163
00:09:19,010 --> 00:09:16,770

you have an allowable for your material

164
00:09:22,430 --> 00:09:19,020
in shear whatever it is if you're

165
00:09:26,180 --> 00:09:22,440
working with yield you put in the shear

166
00:09:27,860 --> 00:09:26,190
yield allowable and if it's ultimate you

167
00:09:30,020 --> 00:09:27,870
put in the ultimate allowable then the

168
00:09:32,300 --> 00:09:30,030
length of engagement now that length of

169
00:09:36,260 --> 00:09:32,310
engagement is a length of full thread

170
00:09:39,950 --> 00:09:36,270
engagement the denominator has the 3 in

171
00:09:42,490 --> 00:09:39,960
it if you were going to be totally

172
00:09:46,280 --> 00:09:42,500
theoretical about it you had a perfectly

173
00:09:48,440 --> 00:09:46,290
mated threads then that bigger could go

174
00:09:50,510 --> 00:09:48,450
down as low as 2 because actually if you

175
00:09:52,940 --> 00:09:50,520
visualize it for a moment what you're

176
00:09:56,519 --> 00:09:52,950
doing you're pulling out a little

177
00:09:59,009 --> 00:09:56,529
cylindrical shell and if you

178
00:10:02,399 --> 00:09:59,019
things exactly at the pitch diameter so

179
00:10:05,399 --> 00:10:02,409
the the external internal thread were

180
00:10:07,229 --> 00:10:05,409
the same then you would be splitting

181
00:10:08,909 --> 00:10:07,239
that little shell between the two of

182
00:10:10,709 --> 00:10:08,919
them so this factor could go all the way

183
00:10:15,179 --> 00:10:10,719
down to two but since threads don't make

184
00:10:18,599 --> 00:10:15,189
that way the three is put in SA fudge

185
00:10:22,769 --> 00:10:18,609
factors I have mentioned mentioned here

186
00:10:27,029 --> 00:10:22,779
and there are some other methods given

187
00:10:32,129 --> 00:10:27,039
in h28 mill handbook h28 for calculating

188
00:10:33,509 --> 00:10:32,139

pull out and once again you can some of

189
00:10:35,369 --> 00:10:33,519
them are a lot more complicated than

190
00:10:37,639 --> 00:10:35,379
what I've done here what I've done if

191
00:10:41,489 --> 00:10:37,649
you have a chance to do it will work so

192
00:10:45,709 --> 00:10:41,499
you can go ahead and go with it now

193
00:10:49,679 --> 00:10:45,719
moving into the fatigue resistant bolt

194
00:10:51,839 --> 00:10:49,689
section of course people usually don't

195
00:10:55,409 --> 00:10:51,849
even think about that and it gets them

196
00:10:59,249 --> 00:10:55,419
in trouble but if you have cyclic

197
00:11:02,249 --> 00:10:59,259
loading on a joint then you need to

198
00:11:05,849 --> 00:11:02,259
minimize the stress risers created

199
00:11:08,099 --> 00:11:05,859
during the manufacturing cycle and some

200
00:11:11,609 --> 00:11:08,109
of these are the threads thread run out

201
00:11:16,249 --> 00:11:11,619
thread Phillip radius and work hardening

202
00:11:20,489 --> 00:11:16,259
through forming of the bolts so you also

203
00:11:23,759 --> 00:11:20,499
have to monitor the installation the

204
00:11:25,549 --> 00:11:23,769
bolt closely to minimize the cycling

205
00:11:28,919 --> 00:11:25,559
modes and of course one of the things

206
00:11:31,859 --> 00:11:28,929
that you do is this is one of the cases

207
00:11:37,349 --> 00:11:31,869
in which Murphy can tighten them up

208
00:11:40,469 --> 00:11:37,359
tight because with a particular knit to

209
00:11:44,489 --> 00:11:40,479
be as tight as possible because it cuts

210
00:11:47,219 --> 00:11:44,499
down on the cyclic loading now one of

211
00:11:49,649 --> 00:11:47,229
the things you can use of course is the

212
00:11:54,599 --> 00:11:49,659
cold fasteners with cold rolled threads

213
00:11:56,789 --> 00:11:54,609

because that gives you the residual

214
00:12:01,229 --> 00:11:56,799
compressive stresses in the thread

215
00:12:03,989 --> 00:12:01,239
surfaces and it gives them more

216
00:12:08,219 --> 00:12:03,999
particular resistance because the TIG

217
00:12:10,020 --> 00:12:08,229
only works in tension so as long as you

218
00:12:12,720 --> 00:12:10,030
keep things in compression

219
00:12:15,510 --> 00:12:12,730
you're right it's just like with glass

220
00:12:17,430 --> 00:12:15,520
they don't worry about cracks and glass

221
00:12:19,020 --> 00:12:17,440
if it's in compression because doesn't

222
00:12:20,240 --> 00:12:19,030
do anything it's just in tension well

223
00:12:23,880 --> 00:12:20,250
it's the same same way here if you

224
00:12:25,380 --> 00:12:23,890
fatigue is compression compression is

225
00:12:29,460 --> 00:12:25,390
fine but tensions where it gets you in

226
00:12:32,370 --> 00:12:29,470
trouble so some of these fasteners as I

227
00:12:35,190 --> 00:12:32,380
mentioned earlier you actually have to

228
00:12:36,510 --> 00:12:35,200
cold roll the threads in order to get it

229
00:12:39,150 --> 00:12:36,520
up the strength that you want it so

230
00:12:41,100 --> 00:12:39,160
that's a good fatigue bolt also the J

231
00:12:42,870 --> 00:12:41,110
threads are better than regular threads

232
00:12:45,720 --> 00:12:42,880
in fatigue because they have the larger

233
00:12:49,040 --> 00:12:45,730
radius then here's one of the other

234
00:12:51,360 --> 00:12:49,050
problems that you can run into that

235
00:12:54,990 --> 00:12:51,370
people every once in a while forget

236
00:12:58,620 --> 00:12:55,000
about is the elongation limits on

237
00:13:01,320 --> 00:12:58,630
materials one of the rules of thumb on

238
00:13:04,680 --> 00:13:01,330

designing of fasteners is don't use a

239
00:13:09,390 --> 00:13:04,690
material at a strength level that has an

240
00:13:12,590 --> 00:13:09,400
elongation below 10% because when you

241
00:13:15,960 --> 00:13:12,600
get down below 10% your stress risers

242
00:13:19,590 --> 00:13:15,970
become much more important as a matter

243
00:13:21,750 --> 00:13:19,600
of fact h-11 tool steel which is used

244
00:13:23,460 --> 00:13:21,760
for high strength fasteners you can get

245
00:13:25,770 --> 00:13:23,470
in trouble and some of the aerospace

246
00:13:27,630 --> 00:13:25,780
companies are backing off on using it at

247
00:13:30,030 --> 00:13:27,640
the real high strength because of that

248
00:13:32,070 --> 00:13:30,040
because it goes down about a 7 or 8

249
00:13:33,930 --> 00:13:32,080
percent elongation and when you get down

250
00:13:39,510 --> 00:13:33,940
that low then you can get brittle

251
00:13:43,829 --> 00:13:39,520
failures now J threads as I mentioned

252
00:13:47,329 --> 00:13:43,839
they're our batter and using countersunk

253
00:13:50,370 --> 00:13:47,339
coursers under the heads to minimize the

254
00:13:53,430 --> 00:13:50,380
washer contact with the Phillip radius

255
00:13:56,970 --> 00:13:53,440
and then if you really want to get

256
00:14:00,950 --> 00:13:56,980
sticky and have a super-duper for taking

257
00:14:04,920 --> 00:14:00,960
tight bolt you can undercut the shank

258
00:14:07,230 --> 00:14:04,930
down to the same diameter as the minor

259
00:14:09,690 --> 00:14:07,240
diameter the threads and this does away

260
00:14:12,480 --> 00:14:09,700
with your stress concentration on your

261
00:14:14,100 --> 00:14:12,490
thread run out because you know having a

262
00:14:16,560 --> 00:14:14,110
run out there because you just have a

263
00:14:19,110 --> 00:14:16,570

smooth shank and when the thread runs

264
00:14:22,590 --> 00:14:19,120
out it runs out on top of the thing more

265
00:14:23,319 --> 00:14:22,600
or less so so that a undercut diameter

266
00:14:26,169 --> 00:14:23,329
fastener

267
00:14:29,079 --> 00:14:26,179
is better in fatigue than one a regular

268
00:14:35,710 --> 00:14:29,089
fastener where the shank diameter is

269
00:14:40,150 --> 00:14:35,720
normally equal to the major diameter of

270
00:14:46,720 --> 00:14:40,160
the threads now the hardness of nut less

271
00:14:53,049 --> 00:14:46,730
than bolt hardness that one can be very

272
00:14:56,169 --> 00:14:53,059
much a problem in some cases since the

273
00:14:59,019 --> 00:14:56,179
bolt load is initially reacted on the

274
00:15:01,210 --> 00:14:59,029
first one or two threads and then has to

275
00:15:04,840 --> 00:15:01,220
deform something in order to spread it

276
00:15:07,619 --> 00:15:04,850
out you want your nut to be softer than

277
00:15:12,699 --> 00:15:07,629
the bolt so you can spread your load out

278
00:15:16,059 --> 00:15:12,709
and a rule of thumb is that the maximum

279
00:15:18,009 --> 00:15:16,069
hardness of the nut should not exceed

280
00:15:20,949 --> 00:15:18,019
the minimum hardness of the bolt and

281
00:15:24,009 --> 00:15:20,959
that's even stretching it normally you

282
00:15:27,639 --> 00:15:24,019
would want it to be for instance a

283
00:15:30,759 --> 00:15:27,649
hundred and sixty ksi bolt you use a 125

284
00:15:34,629 --> 00:15:30,769
145 nut on it in order to distribute the

285
00:15:36,039 --> 00:15:34,639
load now this court case that I

286
00:15:39,329 --> 00:15:36,049
mentioned to you earlier the chair

287
00:15:44,499 --> 00:15:39,339
failure that was the thing that caused

288
00:15:46,749 --> 00:15:44,509

that chair to fail was that they this

289
00:15:50,169 --> 00:15:46,759
furniture manufacturers don't have too

290
00:15:51,699 --> 00:15:50,179
many fatigue engineers on the job they

291
00:15:53,350 --> 00:15:51,709
go out up the hardware store buy

292
00:15:55,269 --> 00:15:53,360
whatever's cheapest and they bought the

293
00:15:57,729 --> 00:15:55,279
bolts from one place and the nuts from

294
00:16:02,169 --> 00:15:57,739
another place and this deformed thread

295
00:16:03,970 --> 00:16:02,179
nut in deforming it they had actually

296
00:16:07,629 --> 00:16:03,980
worked hardened it to where it was

297
00:16:10,389 --> 00:16:07,639
harder than the bolt so what it did when

298
00:16:12,879 --> 00:16:10,399
they put it on it just stripped the

299
00:16:16,269 --> 00:16:12,889
threads the boldest that was going on

300
00:16:18,639 --> 00:16:16,279
and then in a matter of about six months

301
00:16:20,079 --> 00:16:18,649
this guy is brand new chair fell apart

302
00:16:22,929 --> 00:16:20,089
and set him for a ride

303
00:16:27,790 --> 00:16:22,939
so he sued the furniture company and

304
00:16:30,850 --> 00:16:27,800
that's where I got in on it but

305
00:16:37,180 --> 00:16:30,860
here's a desirable joint loading diagram

306
00:16:39,970 --> 00:16:37,190
now you want a stiffness fastener joint

307
00:16:41,410 --> 00:16:39,980
stiffness ratio of five or higher and

308
00:16:43,780 --> 00:16:41,420
we'll go through some of the things on

309
00:16:47,260 --> 00:16:43,790
calculating joint stiffness fastener

310
00:16:52,690 --> 00:16:47,270
stiffness and so on to minimize the

311
00:16:54,940 --> 00:16:52,700
cyclic loading on the fastener and

312
00:16:56,530 --> 00:16:54,950
coming back again I keep repeating this

313
00:16:59,050 --> 00:16:56,540

one but it's worth repeating avoid

314
00:17:03,100 --> 00:16:59,060
capped holes if you can don't use them

315
00:17:04,810 --> 00:17:03,110
unless you have to I was on a design

316
00:17:07,810 --> 00:17:04,820
review here one time in which this young

317
00:17:09,490 --> 00:17:07,820
engineer came up with a design and he

318
00:17:12,370 --> 00:17:09,500
had heard that when you used aluminum

319
00:17:15,370 --> 00:17:12,380
you were supposed to use inserts so

320
00:17:17,170 --> 00:17:15,380
instead of bolting through he put

321
00:17:18,820 --> 00:17:17,180
through holes in butt tap them for

322
00:17:22,500 --> 00:17:18,830
inserts because after all you're

323
00:17:24,880 --> 00:17:22,510
supposed to use inserts in aluminum but

324
00:17:28,900 --> 00:17:24,890
if you have a chance to use through

325
00:17:31,420 --> 00:17:28,910
bolting that is the most efficient most

326
00:17:33,670 --> 00:17:31,430
trouble-free way of doing it regardless

327
00:17:36,100 --> 00:17:33,680
of what what you're bolting in all right

328
00:17:41,410 --> 00:17:36,110
now the tap holes are cut rather than

329
00:17:44,830 --> 00:17:41,420
rolled and the radius of a tap Pole is

330
00:17:47,260 --> 00:17:44,840
not measured normally if you want it

331
00:17:49,600 --> 00:17:47,270
measured it's a lot of trouble so you

332
00:17:51,970 --> 00:17:49,610
could get all sorts of undetected stress

333
00:17:53,410 --> 00:17:51,980
risers because think had it from a

334
00:17:57,130 --> 00:17:53,420
practical standpoint you've got a

335
00:17:58,900 --> 00:17:57,140
quarter inch hole inspector is gonna go

336
00:18:00,340 --> 00:17:58,910
up and look down in it and say yep

337
00:18:01,630 --> 00:18:00,350
there's all there it looks alright to me

338
00:18:06,240 --> 00:18:01,640

and that's about the amount of

339
00:18:09,670 --> 00:18:06,250
inspection you'll get on it now use a

340
00:18:12,730 --> 00:18:09,680
lot of small diameter bolts if you can

341
00:18:16,600 --> 00:18:12,740
in order to give you a more elastic

342
00:18:20,050 --> 00:18:16,610
system because the that gives you a

343
00:18:24,250 --> 00:18:20,060
better ratio of bolts joint stiffness to

344
00:18:27,220 --> 00:18:24,260
fastener stiffness and of course that

345
00:18:30,370 --> 00:18:27,230
kicks a labour cost up so you have to

346
00:18:34,230 --> 00:18:30,380
wait to see which what you're going to

347
00:18:36,970 --> 00:18:34,240
do in order to make the joint survive

348
00:18:39,130 --> 00:18:36,980
now the other thing you you have to do

349
00:18:40,830 --> 00:18:39,140
is consider the thermal loading and the

350
00:18:42,630 --> 00:18:40,840
joint remember I mentioned

351
00:18:46,560 --> 00:18:42,640
earlier about using Belleville washers

352
00:18:48,570 --> 00:18:46,570
to give you a longer spring constant if

353
00:18:52,710 --> 00:18:48,580
you will and a bolted joint to take the

354
00:18:55,110 --> 00:18:52,720
thermal cycling and particularly if the

355
00:18:59,039 --> 00:18:55,120
bolt and the joint materials are

356
00:19:01,680 --> 00:18:59,049
different then you have to watch it

357
00:19:04,560 --> 00:19:01,690
closely we had a problem on the center

358
00:19:07,830 --> 00:19:04,570
vehical when they were using good old 80

359
00:19:10,230 --> 00:19:07,840
to 86 bolts on aluminum flanges the only

360
00:19:13,440 --> 00:19:10,240
thing is they tighten them up Terk them

361
00:19:15,690 --> 00:19:13,450
down at room temperature then when they

362
00:19:18,360 --> 00:19:15,700
tanked up with liquid hydrogen and

363
00:19:23,789 --> 00:19:18,370

liquid oxygen the temperature went down

364
00:19:27,840 --> 00:19:23,799
to something like minus 300 the aluminum

365
00:19:31,500 --> 00:19:27,850
shrink and it started leaking because

366
00:19:34,049 --> 00:19:31,510
the bolts got loose so they like to

367
00:19:35,669 --> 00:19:34,059
never hit a happy balance on that of

368
00:19:36,990 --> 00:19:35,679
getting bolts the fact they had to get

369
00:19:39,330 --> 00:19:37,000
higher strength bolts and they could

370
00:19:41,130 --> 00:19:39,340
crank the torque up so that the thing

371
00:19:43,409 --> 00:19:41,140
would be alright at room temperature and

372
00:19:45,510 --> 00:19:43,419
still not leak at the cryogenic

373
00:19:47,570 --> 00:19:45,520
temperature so this is a this is a

374
00:19:50,130 --> 00:19:47,580
problem you have to be careful about

375
00:19:52,769 --> 00:19:50,140
then here's the other thing that that

376
00:19:54,630 --> 00:19:52,779
you should do this is one of the few

377
00:19:57,690 --> 00:19:54,640
places that I agree with some of the

378
00:20:00,269 --> 00:19:57,700
automotive companies on is turcica

379
00:20:03,750 --> 00:20:00,279
fasteners close to yield point if it's a

380
00:20:06,480 --> 00:20:03,760
fatigue joint and if you do enough

381
00:20:08,940 --> 00:20:06,490
testing to determine where it is then

382
00:20:12,120 --> 00:20:08,950
you can torque up to 90 to 95% of yield

383
00:20:15,870 --> 00:20:12,130
and the higher preload decreases the

384
00:20:20,039 --> 00:20:15,880
cyclic loading and I have some figures

385
00:20:23,159 --> 00:20:20,049
here to indicate this if you want to

386
00:20:27,779 --> 00:20:23,169
leaf back and forth between 10 7 and 10

387
00:20:29,940 --> 00:20:27,789
8 the or I'll tell you what if you will

388
00:20:34,200 --> 00:20:29,950

go to the next page with the the graph

389
00:20:37,769 --> 00:20:34,210
there and and then bets it can keep hers

390
00:20:43,680 --> 00:20:37,779
where it is there we go now we work back

391
00:20:48,810 --> 00:20:43,690
and forth on here here is the initial

392
00:20:50,610 --> 00:20:48,820
loading here is yield so we're so here's

393
00:20:52,240 --> 00:20:50,620
the initial loading before putting

394
00:20:56,950 --> 00:20:52,250
external load on the thing

395
00:20:59,649 --> 00:20:56,960
now when you put the load on the cyclic

396
00:21:04,360 --> 00:20:59,659
loading on the fastener is just the part

397
00:21:06,310 --> 00:21:04,370
between here and here so if as you'll

398
00:21:09,039 --> 00:21:06,320
see when I show the the next one of

399
00:21:11,230 --> 00:21:09,049
these where I deliberately put the two

400
00:21:14,500 --> 00:21:11,240
points closer together you get lost what

401
00:21:16,330 --> 00:21:14,510
les cycling then this is the clamping

402
00:21:20,380 --> 00:21:16,340
load remaining when you go all the way

403
00:21:22,299 --> 00:21:20,390
up to yield now this represents the

404
00:21:25,240 --> 00:21:22,309
stiffness of the bolt and this

405
00:21:28,570 --> 00:21:25,250
represents the stiffness of the joint so

406
00:21:30,940 --> 00:21:28,580
if you get a better ratio between the

407
00:21:33,960 --> 00:21:30,950
two and lean those lines over a little

408
00:21:36,940 --> 00:21:33,970
bit you get less cyclic loading on the

409
00:21:39,070 --> 00:21:36,950
bolt when you apply an external load now

410
00:21:40,750 --> 00:21:39,080
if you go over here we're torque above

411
00:21:43,750 --> 00:21:40,760
yield because here's a yield point

412
00:21:46,120 --> 00:21:43,760
there's above yield then on this one we

413
00:21:48,340 --> 00:21:46,130

really applied two loads that took it

414
00:21:53,440 --> 00:21:48,350
way above yield and failed it it

415
00:22:03,399 --> 00:21:53,450
separated so now if you look at the ten

416
00:22:05,740 --> 00:22:03,409
point nine there I put the the initial

417
00:22:08,440 --> 00:22:05,750
preload and yield are fairly close

418
00:22:11,919 --> 00:22:08,450
together so you see the cyclic loading

419
00:22:14,919 --> 00:22:11,929
is just the between here so therefore

420
00:22:19,060 --> 00:22:14,929
you get less cyclic loading with the

421
00:22:21,610 --> 00:22:19,070
higher torque on the fasteners now this

422
00:22:25,740 --> 00:22:21,620
figure was over torqued

423
00:22:28,360 --> 00:22:25,750
if you notice it's kind of Wiggly here

424
00:22:30,789 --> 00:22:28,370
that's the over Turk trying to scan it

425
00:22:37,049 --> 00:22:30,799
into the scanner and it wouldn't scan in

426
00:22:47,020 --> 00:22:41,430
okay moving on now to fastener torque

427
00:22:48,700 --> 00:22:47,030
which is 11:1 now determination of

428
00:22:51,549 --> 00:22:48,710
torque values is one of the most

429
00:22:55,180 --> 00:22:51,559
difficult and controversial aspects of

430
00:22:58,180 --> 00:22:55,190
fastener design and if you tuck to

431
00:23:00,610 --> 00:22:58,190
Murphy he says if tight is good a little

432
00:23:02,230 --> 00:23:00,620
tighter is better but it doesn't always

433
00:23:08,919 --> 00:23:02,240
work out that way Murphy's a guy that

434
00:23:12,580 --> 00:23:08,929
runs the wrenches but the variables

435
00:23:14,440 --> 00:23:12,590
involved the joint material strength the

436
00:23:17,350 --> 00:23:14,450
coefficient of friction between mating

437
00:23:19,840 --> 00:23:17,360
surfaces the effect of friction between

438
00:23:23,440 --> 00:23:19,850

the bolt head and nut or its mating

439
00:23:25,720 --> 00:23:23,450
surface and the effect of coatings and

440
00:23:27,669 --> 00:23:25,730
lubricants on the friction coefficients

441
00:23:30,100 --> 00:23:27,679
themselves because the amount of

442
00:23:36,370 --> 00:23:30,110
lubricant you put on changes it all

443
00:23:38,230 --> 00:23:36,380
together now the percentage of bolt

444
00:23:41,310 --> 00:23:38,240
tensile strength that you want for

445
00:23:45,430 --> 00:23:41,320
preload that is something that is

446
00:23:48,970 --> 00:23:45,440
difficult one of our guys just to show

447
00:23:52,560 --> 00:23:48,980
you how how things can vary one of our

448
00:23:56,560 --> 00:23:52,570
guys had some a stainless steel bolt nut

449
00:23:58,810 --> 00:23:56,570
assembly that had been locks cleaned now

450
00:24:01,360 --> 00:23:58,820
locks cleaned is like ultrasonically

451
00:24:05,680 --> 00:24:01,370
cleaning your jewelry or something like

452
00:24:07,930 --> 00:24:05,690
that it is clean clean and he was

453
00:24:11,110 --> 00:24:07,940
required to have it that clean so he

454
00:24:13,270 --> 00:24:11,120
went to assemble it he had used up his

455
00:24:18,039 --> 00:24:13,280
allowable torque before you got it

456
00:24:20,799 --> 00:24:18,049
seated because dry dry clean stainless

457
00:24:23,020 --> 00:24:20,809
on dry clean stainless has a real high

458
00:24:24,850 --> 00:24:23,030
coefficient of friction so this just

459
00:24:28,840 --> 00:24:24,860
shows you what you can do going to an

460
00:24:31,120 --> 00:24:28,850
extreme now the other thing is what is

461
00:24:34,570 --> 00:24:31,130
the distribution of total torque to

462
00:24:36,610 --> 00:24:34,580
tension shear and friction you know when

463
00:24:40,029 --> 00:24:36,620

you twerk up a fastener that you have a

464
00:24:41,890 --> 00:24:40,039
certain torque value applied but you

465
00:24:43,779 --> 00:24:41,900
don't know how much of it went into

466
00:24:48,039 --> 00:24:43,789
tension how much of it went into shear

467
00:24:50,169 --> 00:24:48,049
and and how much of it has lost the

468
00:24:52,690 --> 00:24:50,179
friction but it all has to be accounted

469
00:24:56,200 --> 00:24:52,700
or then the other thing is the relative

470
00:24:58,840 --> 00:24:56,210
spring rates the bolts and nuts and the

471
00:25:00,609 --> 00:24:58,850
joints themselves and then accounting

472
00:25:03,430 --> 00:25:00,619
for the running torque of the locking

473
00:25:06,159 --> 00:25:03,440
devices all those different methods of

474
00:25:09,129 --> 00:25:06,169
locking themselves have at what is

475
00:25:12,999 --> 00:25:09,139
called a running torque that has to be

476
00:25:14,859 --> 00:25:13,009
accounted for now head friction if the

477
00:25:16,539 --> 00:25:14,869
fastener is tightened from the head the

478
00:25:20,499 --> 00:25:16,549
bearing surface for the bottom of the

479
00:25:23,200 --> 00:25:20,509
head becomes a big part of the friction

480
00:25:25,930 --> 00:25:23,210
load that's why that having a smooth

481
00:25:29,639 --> 00:25:25,940
washer hardened washer under the head is

482
00:25:32,619 --> 00:25:29,649
a good idea even if you don't

483
00:25:35,200 --> 00:25:32,629
necessarily have to have it it's good

484
00:25:36,970 --> 00:25:35,210
because it gives you a hardened surface

485
00:25:39,539 --> 00:25:36,980
that will have a lower coefficient of

486
00:25:43,690 --> 00:25:39,549
friction than the joint material itself

487
00:25:46,359 --> 00:25:43,700
plus the washer will deter or prevent

488
00:25:48,669 --> 00:25:46,369

embedment of the head where the joint

489
00:25:49,980 --> 00:25:48,679
material is softer than the boat which

490
00:25:53,320 --> 00:25:49,990
is usually the case

491
00:25:56,560 --> 00:25:53,330
now if head friction locking is desired

492
00:25:59,350 --> 00:25:56,570
then you can maximize that head friction

493
00:26:02,379 --> 00:25:59,360
use remember earlier I covered the

494
00:26:04,869 --> 00:26:02,389
serrated head with that you could use

495
00:26:07,720 --> 00:26:04,879
without a washer or don't use any

496
00:26:10,539 --> 00:26:07,730
lubricant on the thing and then then of

497
00:26:13,299 --> 00:26:10,549
course you will use up more of your

498
00:26:14,980 --> 00:26:13,309
torque on friction and have less in it

499
00:26:22,330 --> 00:26:14,990
and axial load which you have to account

500
00:26:27,789 --> 00:26:22,340
for nut friction pretty much the same

501
00:26:30,789 --> 00:26:27,799
thing you can you can go either way you

502
00:26:33,639 --> 00:26:30,799
can maximize it or minimize it by using

503
00:26:35,769 --> 00:26:33,649
lubricants and stuff like that and the

504
00:26:37,659 --> 00:26:35,779
nut usually contains a locking device

505
00:26:39,879 --> 00:26:37,669
it's easier to install a locking device

506
00:26:43,539 --> 00:26:39,889
on a nut normally than it is on the

507
00:26:47,109 --> 00:26:43,549
bolts so most of the nuts carry the

508
00:26:49,239 --> 00:26:47,119
locking device so the running torque the

509
00:26:51,519 --> 00:26:49,249
locking device and I'll go through

510
00:26:54,310 --> 00:26:51,529
definitions on it but the running torque

511
00:26:57,609 --> 00:26:54,320
is the amount that it takes just to seek

512
00:27:02,010 --> 00:26:57,619
the thing down to the surface and it's

513
00:27:08,340 --> 00:27:02,020

usually a small fraction of the total

514
00:27:13,770 --> 00:27:08,350
now the k-factor people say T equals

515
00:27:17,340 --> 00:27:13,780
2/10 F D and that 2/10 is used

516
00:27:20,610 --> 00:27:17,350
religiously well at 2/10 is this budge

517
00:27:24,240 --> 00:27:20,620
factor which has this formula right here

518
00:27:27,090 --> 00:27:24,250
and for those of you who have a copy my

519
00:27:29,430 --> 00:27:27,100
fastener manual I'd I had the right

520
00:27:33,360 --> 00:27:29,440
calculations in the manual but I had the

521
00:27:35,430 --> 00:27:33,370
wrong terminology I had a Greek sigh for

522
00:27:37,350 --> 00:27:35,440
this this angle here it should have been

523
00:27:39,240 --> 00:27:37,360
lambda according to the formula and I

524
00:27:42,510 --> 00:27:39,250
the calculations were done right the

525
00:27:44,730 --> 00:27:42,520
terminology was wrong in it but anyway

526
00:27:51,330 --> 00:27:44,740
this is this is the formula that you use

527
00:27:53,460 --> 00:27:51,340
for calculating that K factor now the D

528
00:27:55,890 --> 00:27:53,470
sub M is the mean thread diameter which

529
00:28:00,480 --> 00:27:55,900
you use pitch diameter for lambda is the

530
00:28:05,419 --> 00:28:00,490
thread lead angle and mu here is the

531
00:28:12,510 --> 00:28:09,500
alpha is the thread angle in this case

532
00:28:15,720 --> 00:28:12,520
since you have a 60 degree angle it's

533
00:28:17,190 --> 00:28:15,730
half of that which is 30 and u sub c is

534
00:28:19,740 --> 00:28:17,200
the friction coefficient between the

535
00:28:21,780 --> 00:28:19,750
bolt head or nut and the clamping

536
00:28:24,180 --> 00:28:21,790
surface so if you throw all those

537
00:28:26,370 --> 00:28:24,190
together and you're able to determine

538
00:28:28,470 --> 00:28:26,380

them well enough that you feel that you

539
00:28:30,630 --> 00:28:28,480
have some confidence in them then you

540
00:28:36,180 --> 00:28:30,640
run a calculation and get an actual

541
00:28:42,150 --> 00:28:36,190
value for that k factor now I did some

542
00:28:44,450 --> 00:28:42,160
calculations using these coefficients of

543
00:28:46,950 --> 00:28:44,460
friction and in this case I used

544
00:28:50,900 --> 00:28:46,960
identical ones although you could have

545
00:28:54,450 --> 00:28:50,910
different ones that doesn't for the

546
00:28:57,540 --> 00:28:54,460
between threads and between the bolt or

547
00:29:00,960 --> 00:28:57,550
or nut and look at the variation that

548
00:29:04,740 --> 00:29:00,970
you can get with the variation in

549
00:29:07,710 --> 00:29:04,750
friction coefficient you see the the K

550
00:29:12,450 --> 00:29:07,720
factor the point two that we use is

551
00:29:15,090 --> 00:29:12,460
actually a little bit high because it

552
00:29:20,940 --> 00:29:15,100
would be somewhere in here would be

553
00:29:25,580 --> 00:29:20,950
a more realistic value however one of

554
00:29:29,490 --> 00:29:25,590
the objections to using zinc plating is

555
00:29:33,149 --> 00:29:29,500
that the friction coefficient with zinc

556
00:29:37,200 --> 00:29:33,159
can vary enough that that value can go

557
00:29:43,320 --> 00:29:37,210
anywhere from point forward up to almost

558
00:29:45,149 --> 00:29:43,330
1 so now when you do this then most of

559
00:29:47,759 --> 00:29:45,159
the torque that you're applying is going

560
00:29:52,789 --> 00:29:47,769
into overcoming friction and your axial

561
00:29:59,700 --> 00:29:55,830
here are some torque definitions and

562
00:30:04,590 --> 00:29:59,710
these are courtesy of sae AS 1310 and

563
00:30:08,399 --> 00:30:04,600

marshall standard 486 and some of them

564
00:30:11,610 --> 00:30:08,409
have been cleaned up slightly to make

565
00:30:14,639 --> 00:30:11,620
them a little more readable because

566
00:30:17,909 --> 00:30:14,649
they've gotten kind of out of hand

567
00:30:21,690 --> 00:30:17,919
so just for torque itself it's of course

568
00:30:24,090 --> 00:30:21,700
it's a force times a distance and you

569
00:30:25,590 --> 00:30:24,100
have a moment arm which is the length of

570
00:30:27,149 --> 00:30:25,600
your torque wrench and then of course

571
00:30:30,029 --> 00:30:27,159
that you put on it and if you have a

572
00:30:31,440 --> 00:30:30,039
torque wrench it'll it'll vary or we'll

573
00:30:33,299 --> 00:30:31,450
register the amount of torque that

574
00:30:34,919 --> 00:30:33,309
you're putting on or if you have the one

575
00:30:37,259 --> 00:30:34,929
of the old do-it-yourselfers it has a

576
00:30:39,659 --> 00:30:37,269
needle on it and you measure it by

577
00:30:41,999 --> 00:30:39,669
deflecting the rod and that one is a

578
00:30:43,769 --> 00:30:42,009
plus or minus 40 percent depending on

579
00:30:45,330 --> 00:30:43,779
whether you can hold it in place long

580
00:30:48,930 --> 00:30:45,340
enough to read it while you're doing the

581
00:30:50,340 --> 00:30:48,940
turkey the applied torque is the torque

582
00:30:52,619 --> 00:30:50,350
transmitted to the fastener of the

583
00:30:54,629 --> 00:30:52,629
installation tool and then you the

584
00:30:56,070 --> 00:30:54,639
running or prevailing torque is the

585
00:31:05,909 --> 00:30:56,080
amount to overcome the locking device

586
00:31:11,159 --> 00:31:08,649
and here are some other definitions the

587
00:31:14,169 --> 00:31:11,169
double torque or retorque

588
00:31:17,289 --> 00:31:14,179

to seek materials being joined where you

589
00:31:21,779 --> 00:31:17,299
had interferences or sheet gaps or form

590
00:31:25,840 --> 00:31:21,789
in place gaskets and stuff like that and

591
00:31:27,729 --> 00:31:25,850
also where you turn around one time in a

592
00:31:30,759 --> 00:31:27,739
circle of bolts and then you need to go

593
00:31:32,710 --> 00:31:30,769
back and check them the the no load

594
00:31:34,749 --> 00:31:32,720
torque is the torque required to

595
00:31:36,820 --> 00:31:34,759
overcome kinetic friction between mating

596
00:31:39,159 --> 00:31:36,830
threads without a locking device and

597
00:31:40,960 --> 00:31:39,169
that is usually unless you have threads

598
00:31:45,129 --> 00:31:40,970
that are damaged or something that is

599
00:31:48,669 --> 00:31:45,139
usually next to nothing then the

600
00:31:50,830 --> 00:31:48,679
installation torque design torque

601
00:31:56,560 --> 00:31:50,840
applied the tightening direction and

602
00:32:01,210 --> 00:31:56,570
includes kinetic static friction self

603
00:32:03,340 --> 00:32:01,220
locking features and required to apply a

604
00:32:06,009 --> 00:32:03,350
desired axial load to the fastener

605
00:32:08,619 --> 00:32:06,019
assembly so its measured in the

606
00:32:10,810 --> 00:32:08,629
tightening direction only and of course

607
00:32:14,109 --> 00:32:10,820
the the thing that is usually in

608
00:32:17,289 --> 00:32:14,119
determinants are not indeterminate but

609
00:32:20,590 --> 00:32:17,299
hard to determine is how much actually a

610
00:32:24,399 --> 00:32:20,600
load do you really get for a given

611
00:32:26,200 --> 00:32:24,409
torque and here's limiting torque and so

612
00:32:28,599 --> 00:32:26,210
on which you can read through these

613
00:32:30,779 --> 00:32:28,609

multiple torque required to see parts

614
00:32:36,789 --> 00:32:30,789
where you have heavy interferences and

615
00:32:39,099 --> 00:32:36,799
assembly and one of these has to do with

616
00:32:41,080 --> 00:32:39,109
where if you're torquing fasteners on a

617
00:32:42,789 --> 00:32:41,090
flange or if you're torquing the lug

618
00:32:45,869 --> 00:32:42,799
bolts on your car or something you know

619
00:32:49,739 --> 00:32:45,879
you always talk 180 degrees apart and

620
00:32:53,320 --> 00:32:49,749
after you get them snug down so that you

621
00:32:55,060 --> 00:32:53,330
get the effect of the adjacent fastener

622
00:32:56,320 --> 00:32:55,070
to the one that you're talking down to

623
00:32:59,409 --> 00:32:56,330
make sure you're going to tighten down

624
00:33:01,989 --> 00:32:59,419
because if you if you tighten tighten

625
00:33:03,970 --> 00:33:01,999
them down and then tighten one down the

626
00:33:07,269 --> 00:33:03,980
one next to it will have a slight amount

627
00:33:10,840 --> 00:33:07,279
of loosening due to the give of the

628
00:33:13,119 --> 00:33:10,850
flange itself so you have to go back and

629
00:33:16,239 --> 00:33:13,129
recheck them back to guy by the name of

630
00:33:18,460 --> 00:33:16,249
George Bible formerly of the University

631
00:33:22,060 --> 00:33:18,470
of Akron came up with a

632
00:33:25,510 --> 00:33:22,070
pewter eyes program on dealing with

633
00:33:27,880 --> 00:33:25,520
large flanges and we're talking near

634
00:33:32,860 --> 00:33:27,890
six-foot flanges or something like that

635
00:33:35,620 --> 00:33:32,870
on the iterative process for doing the

636
00:33:38,049 --> 00:33:35,630
Turks on them to get them all Turk down

637
00:33:40,419 --> 00:33:38,059
within satisfactory limits and gave a

638
00:33:43,120 --> 00:33:40,429

presentation one time at the voting

639
00:33:46,510 --> 00:33:43,130
Technology Council now here's the

640
00:33:49,270 --> 00:33:46,520
seating torque and that's just to bring

641
00:33:51,360 --> 00:33:49,280
the bearing faces into a seated position

642
00:33:54,340 --> 00:33:51,370
and then the the break loose torque

643
00:33:55,899 --> 00:33:54,350
torque required to loosen the fastener

644
00:33:57,909 --> 00:33:55,909
from its installed position there's

645
00:34:01,510 --> 00:33:57,919
various other definitions that get too

646
00:34:03,580 --> 00:34:01,520
confusing and Harold Casper and I went

647
00:34:06,669 --> 00:34:03,590
through them and eliminated some of them

648
00:34:08,379 --> 00:34:06,679
that created too much confusion now

649
00:34:13,000 --> 00:34:08,389
here's the big question what part

650
00:34:16,780 --> 00:34:13,010
tension and that's the most

651
00:34:18,760 --> 00:34:16,790
unpredictable one and the clamp load in

652
00:34:21,550 --> 00:34:18,770
general only represents something like

653
00:34:23,099 --> 00:34:21,560
10 to 25% of the applied torque because

654
00:34:26,379 --> 00:34:23,109
the rest of it is used to overcome

655
00:34:30,550 --> 00:34:26,389
friction and various other things in the

656
00:34:33,720 --> 00:34:30,560
joint so but the thing that you've got

657
00:34:36,490 --> 00:34:33,730
to look at is just because you put a

658
00:34:38,290 --> 00:34:36,500
certain amount of torque into a fastener

659
00:34:41,169 --> 00:34:38,300
and it doesn't have a lot of axial load

660
00:34:45,030 --> 00:34:41,179
on it doesn't mean that that torque went

661
00:34:47,290 --> 00:34:45,040
away it's still in there and shir

662
00:34:49,629 --> 00:34:47,300
somewhere it has to be accounted for so

663
00:34:51,970 --> 00:34:49,639

that's why you got to be careful on over

664
00:34:55,210 --> 00:34:51,980
torquing stuff and you got to combine

665
00:34:58,359 --> 00:34:55,220
stresses and check them all against the

666
00:35:02,109 --> 00:34:58,369
total strength of the fastener so and of

667
00:35:05,710 --> 00:35:02,119
course this is the thing here that the

668
00:35:07,359 --> 00:35:05,720
von Mises stresses can be calculated and

669
00:35:14,500 --> 00:35:07,369
compared to yield and ultimate strength

670
00:35:18,010 --> 00:35:14,510
of the material so or for those of you

671
00:35:20,680 --> 00:35:18,020
who feel academically inclined you could

672
00:35:22,720 --> 00:35:20,690
use a Mohr circle and take share in

673
00:35:25,120 --> 00:35:22,730
tension and plot them out and get all

674
00:35:29,650 --> 00:35:25,130
that sort of thing but stress ratios

675
00:35:32,390 --> 00:35:29,660
work better so and their artwork values

676
00:35:34,760 --> 00:35:32,400
and these are tongue-in-cheek not

677
00:35:36,799 --> 00:35:34,770
one's for both inch and metric fasteners

678
00:35:43,220 --> 00:35:36,809
in the appendices which you would get

679
00:35:44,930 --> 00:35:43,230
layer clerk accuracies it's only as good

680
00:35:48,079 --> 00:35:44,940
as the type of measuring device in the

681
00:35:50,210 --> 00:35:48,089
operator and of all these methods the

682
00:35:53,000 --> 00:35:50,220
worst one of all is the impact wrench

683
00:35:57,799 --> 00:35:53,010
Joe Greenslade who is a writer

684
00:35:59,720 --> 00:35:57,809
in the fastener world put out an article

685
00:36:03,170 --> 00:35:59,730
here sometime back then I got a chuckle

686
00:36:03,769 --> 00:36:03,180
out of he believe it was titled impact

687
00:36:09,620 --> 00:36:03,779
wrench

688
00:36:11,870 --> 00:36:09,630

the engineers worst enemy because the

689
00:36:15,650 --> 00:36:11,880
impact wrenches that these garages use

690
00:36:18,079 --> 00:36:15,660
are never calibrated probably and they

691
00:36:20,420 --> 00:36:18,089
put them on real good and tight and then

692
00:36:22,849 --> 00:36:20,430
you need a truck breaker bar to get your

693
00:36:26,210 --> 00:36:22,859
lug nuts loose on your car when you go

694
00:36:31,609 --> 00:36:26,220
to take it off so so that's the worst

695
00:36:34,160 --> 00:36:31,619
one and if a perk wrench is used to

696
00:36:37,640 --> 00:36:34,170
apply torque the applied torque should

697
00:36:40,390 --> 00:36:37,650
be at least 70% a full scale of the

698
00:36:43,700 --> 00:36:40,400
wrench in other words don't use a

699
00:36:45,380 --> 00:36:43,710
hundred and seventy five foot pound

700
00:36:48,079 --> 00:36:45,390
torque wrench with a number eight

701
00:36:49,400 --> 00:36:48,089
fastener because there's no accuracy

702
00:36:51,260 --> 00:36:49,410
there just like it is with any other

703
00:36:55,730 --> 00:36:51,270
reading if you're doing instrumentation

704
00:36:59,930 --> 00:36:55,740
you try to get say 70% of full scale in

705
00:37:01,910 --> 00:36:59,940
the range of your actual measurements

706
00:37:06,710 --> 00:37:01,920
that you're making because you don't

707
00:37:08,420 --> 00:37:06,720
since the tolerances are a percentage

708
00:37:10,339 --> 00:37:08,430
you won't you do not want to be

709
00:37:12,470 --> 00:37:10,349
measuring in the bottom 10% of your

710
00:37:16,370 --> 00:37:12,480
scale when you're making readings on

711
00:37:21,099 --> 00:37:16,380
anything now

712
00:37:24,019 --> 00:37:21,109
here is a table with approximate values

713
00:37:29,210 --> 00:37:24,029

for Terk measuring methods versus the

714
00:37:33,500 --> 00:37:29,220
accuracy and cost now you see the feel

715
00:37:36,079 --> 00:37:33,510
there in which the guy just says well

716
00:37:39,250 --> 00:37:36,089
I've been doing this for years so this

717
00:37:43,339 --> 00:37:39,260
is about what this should have on it

718
00:37:45,260 --> 00:37:43,349
cheap way of doing it and a lot of it if

719
00:37:46,309 --> 00:37:45,270
you've been I've been feeling those

720
00:37:50,660 --> 00:37:46,319
joints for years like

721
00:37:53,269 --> 00:37:50,670
that a lot of times it will suffice I

722
00:37:55,969 --> 00:37:53,279
don't use a perk branch on my car unless

723
00:37:57,620 --> 00:37:55,979
there's a specified value called for

724
00:37:58,729 --> 00:37:57,630
like a tie rod end or something like

725
00:38:00,589 --> 00:37:58,739
that where you have to go to a high

726
00:38:03,410 --> 00:38:00,599
torque value then I get out the turqu

727
00:38:06,890 --> 00:38:03,420
wrench otherwise I don't an impact

728
00:38:09,319 --> 00:38:06,900
wrench and it's it's been probably even

729
00:38:12,890 --> 00:38:09,329
worse than that but that's the value

730
00:38:14,509 --> 00:38:12,900
that some of us had agreed to before the

731
00:38:15,939 --> 00:38:14,519
torque wrench that actually gives you a

732
00:38:19,819 --> 00:38:15,949
reading

733
00:38:22,029 --> 00:38:19,829
about plus or minus 25 turn of the nut

734
00:38:27,979 --> 00:38:22,039
now that's a method which I will cover

735
00:38:29,749 --> 00:38:27,989
later which is fairly accurate as long

736
00:38:31,130 --> 00:38:29,759
as you want to use it but you probably

737
00:38:34,069 --> 00:38:31,140
wouldn't want to use it because you go

738
00:38:37,099 --> 00:38:34,079

above yield on the passenger then these

739
00:38:39,829 --> 00:38:37,109
load indicating washers they give pretty

740
00:38:43,029 --> 00:38:39,839
good accuracy but of course the amount

741
00:38:46,039 --> 00:38:43,039
of labor involved runs the cost up

742
00:38:47,839 --> 00:38:46,049
remember I covered those the the one

743
00:38:49,430 --> 00:38:47,849
that had the little bumps on it and the

744
00:38:52,910 --> 00:38:49,440
other one that had the little internal

745
00:38:56,660 --> 00:38:52,920
bushing that you compressed fastener

746
00:39:00,229 --> 00:38:56,670
elongation now that could be used if you

747
00:39:02,930 --> 00:39:00,239
are say bolting a flange and you have a

748
00:39:05,390 --> 00:39:02,940
guy there with a scale an accurate scale

749
00:39:08,420 --> 00:39:05,400
he can actually measure fastener

750
00:39:11,089 --> 00:39:08,430
elongation velocity subtracts out the

751
00:39:14,299 --> 00:39:11,099
dead part that didn't expand on it and

752
00:39:17,539 --> 00:39:14,309
get some idea as to where he's at on it

753
00:39:21,680 --> 00:39:17,549
but then you can go to string gauges now

754
00:39:26,809 --> 00:39:21,690
strain gauges are real accurate but the

755
00:39:28,729 --> 00:39:26,819
only thing is how do you do it how do

756
00:39:30,650 --> 00:39:28,739
you put strain gauges on a bolt etre

757
00:39:34,789 --> 00:39:30,660
installing down in the hole it's kind of

758
00:39:37,400 --> 00:39:34,799
hard to do so so what what you normally

759
00:39:39,559 --> 00:39:37,410
do with the strain gauge is is if you're

760
00:39:42,170 --> 00:39:39,569
really interested in finding exactly

761
00:39:43,819 --> 00:39:42,180
what you want you put them on one of the

762
00:39:46,189 --> 00:39:43,829
bolts and test it under the same

763
00:39:48,489 --> 00:39:46,199

conditions as nearly as you can to

764
00:39:51,259 --> 00:39:48,499
duplicate the actual installation and

765
00:39:54,559 --> 00:39:51,269
get a quick reading from that and then

766
00:39:56,989 --> 00:39:54,569
use that torque reading on the bolt

767
00:39:59,690 --> 00:39:56,999
you're gonna install then of course the

768
00:40:02,000 --> 00:39:59,700
other thing was these direct

769
00:40:06,020 --> 00:40:02,010
and indicating bolts which is kind of a

770
00:40:12,380 --> 00:40:06,030
strain gauge type setup so I will cover

771
00:40:17,030 --> 00:40:12,390
some of those in further texture now

772
00:40:21,470 --> 00:40:17,040
perks draping that is used a lot by the

773
00:40:23,780 --> 00:40:21,480
aerospace companies for after you have

774
00:40:27,470 --> 00:40:23,790
decided the final torque value on a

775
00:40:29,359 --> 00:40:27,480
fastener you actually just take a marker

776
00:40:33,710 --> 00:40:29,369
of some kind they used to use a paint

777
00:40:38,960 --> 00:40:33,720
now we use a blue sharpie pen to mark

778
00:40:42,440 --> 00:40:38,970
across the head or the nut straight

779
00:40:46,550 --> 00:40:42,450
across onto the surrounding surface now

780
00:40:49,640 --> 00:40:46,560
this is a visual indication if the thing

781
00:40:51,260 --> 00:40:49,650
switches position on you because it will

782
00:40:57,170 --> 00:40:51,270
show up because the two marks don't line

783
00:40:59,060 --> 00:40:57,180
up anymore and that is a very common

784
00:41:01,430 --> 00:40:59,070
thing in the aerospace world that way

785
00:41:03,290 --> 00:41:01,440
you can look in later and see whether

786
00:41:07,250 --> 00:41:03,300
anything has changed on your

787
00:41:10,690 --> 00:41:07,260
installation now joint relaxation that's

788
00:41:13,670 --> 00:41:10,700

not what you're going to after today

789
00:41:16,579 --> 00:41:13,680
it's defined it's the unloading of a

790
00:41:19,400 --> 00:41:16,589
fastener after its final torque due to a

791
00:41:21,770 --> 00:41:19,410
number of contributing factors and here

792
00:41:24,559 --> 00:41:21,780
are some of the major factors embedment

793
00:41:27,589 --> 00:41:24,569
of the washer the head or the nut in the

794
00:41:29,540 --> 00:41:27,599
joint material yielding of a high spot

795
00:41:32,710 --> 00:41:29,550
or blemish on the head nut or washer

796
00:41:35,599 --> 00:41:32,720
joint surface after final tightening and

797
00:41:37,670 --> 00:41:35,609
untwisting of a fastener from initial

798
00:41:39,380 --> 00:41:37,680
torsion where the shank had an

799
00:41:41,329 --> 00:41:39,390
interference bit in the hole so you

800
00:41:45,200 --> 00:41:41,339
cranked it down but a lot of that went

801
00:41:51,349 --> 00:41:45,210
in to putting some torsional twist into

802
00:41:53,809 --> 00:41:51,359
the fastener and so after the thing

803
00:41:56,839 --> 00:41:53,819
settles down it kind of makes its way

804
00:41:59,329 --> 00:41:56,849
back creeps back to a equilibrium

805
00:42:01,670 --> 00:41:59,339
position and in doing so that will

806
00:42:03,829 --> 00:42:01,680
lessen the load on the fastener itself

807
00:42:11,660 --> 00:42:03,839
and then creep of the joint material

808
00:42:18,990 --> 00:42:14,220
then here's the other thing I mentioned

809
00:42:21,030 --> 00:42:19,000
on the like the lug nuts on your car a

810
00:42:22,859 --> 00:42:21,040
failure of the Installer to wreak torque

811
00:42:24,960 --> 00:42:22,869
a pattern of fasteners after initial

812
00:42:26,579 --> 00:42:24,970
installation to come compensate for

813
00:42:28,950 --> 00:42:26,589

effects of adjacent fasteners to each

814
00:42:31,049 --> 00:42:28,960
other because when you compress the

815
00:42:34,049 --> 00:42:31,059
surface next to the the fastener you

816
00:42:35,520 --> 00:42:34,059
talked before then it changes the load

817
00:42:39,750 --> 00:42:35,530
on that fastener you got to go back to

818
00:42:41,309 --> 00:42:39,760
return also here's here's one here's why

819
00:42:45,030 --> 00:42:41,319
I don't like to go up to the yield point

820
00:42:47,130 --> 00:42:45,040
on fasteners inadvertently exceeding the

821
00:42:48,809 --> 00:42:47,140
yield point of the fastener during the

822
00:42:51,000 --> 00:42:48,819
initial turkeying process now there

823
00:42:53,579 --> 00:42:51,010
you're in real trouble in fact that's

824
00:42:56,460 --> 00:42:53,589
what they did on that first time around

825
00:42:57,900 --> 00:42:56,470
on that Center volt problems talked

826
00:42:59,309 --> 00:42:57,910
about with the cryogenic temperatures

827
00:43:01,559 --> 00:42:59,319
they say well we just increase the

828
00:43:03,150 --> 00:43:01,569
torque so they increased the torque and

829
00:43:04,950 --> 00:43:03,160
they were yielding some of the fasteners

830
00:43:06,990 --> 00:43:04,960
when they checked them again they were

831
00:43:09,000 --> 00:43:07,000
down to something like 40% of the

832
00:43:12,089 --> 00:43:09,010
initial load so they had to go to higher

833
00:43:13,890 --> 00:43:12,099
strength fasteners then the other thing

834
00:43:15,690 --> 00:43:13,900
is critical joints should be inspected

835
00:43:17,430 --> 00:43:15,700
for relaxation a few hours after

836
00:43:19,079 --> 00:43:17,440
installation you go through and check

837
00:43:23,069 --> 00:43:19,089
them with the same torque and see if any

838
00:43:26,130 --> 00:43:23,079

of them have loosened up any now here's

839
00:43:28,760 --> 00:43:26,140
the turn of the nut process and this is

840
00:43:31,500 --> 00:43:28,770
used in the construction business

841
00:43:35,460 --> 00:43:31,510
because it's something that visually you

842
00:43:38,880 --> 00:43:35,470
can do particularly with a big boat you

843
00:43:41,130 --> 00:43:38,890
tighten the nut above yields so what you

844
00:43:45,329 --> 00:43:41,140
do is you taken it to what you think is

845
00:43:46,620 --> 00:43:45,339
about 75% of ultimate load then put a

846
00:43:50,190 --> 00:43:46,630
mark on it

847
00:43:53,670 --> 00:43:50,200
then turn the nut an additional 180

848
00:43:56,250 --> 00:43:53,680
degrees this brings a bolt stress up

849
00:43:58,859 --> 00:43:56,260
above yield but below ultimate providing

850
00:44:03,510 --> 00:43:58,869
the material is ductile so that yield an

851
00:44:06,359 --> 00:44:03,520
ultimate are far enough apart now that

852
00:44:08,270 --> 00:44:06,369
is not used in the aerospace world

853
00:44:11,789 --> 00:44:08,280
because you don't risk stuff like that

854
00:44:15,599 --> 00:44:11,799
aerospace torque values usually are 50

855
00:44:18,539 --> 00:44:15,609
to 75 percent of yield depending on the

856
00:44:22,520 --> 00:44:18,549
application as to whether you have much

857
00:44:25,079 --> 00:44:22,530
tension on the joint or none and so on

858
00:44:25,710 --> 00:44:25,089
so that because you still have to check

859
00:44:28,859 --> 00:44:25,720
for both

860
00:44:32,630 --> 00:44:28,869
shiron axial load now tightening the

861
00:44:35,070 --> 00:44:32,640
fastener beyond its yield is risky

862
00:44:39,000 --> 00:44:35,080
because it's so difficult to determine

863
00:44:43,470 --> 00:44:39,010

where yield is this is why that if you

864
00:44:45,780 --> 00:44:43,480
go look at the definition of yield for a

865
00:44:48,180 --> 00:44:45,790
material in a something like mil

866
00:44:51,530 --> 00:44:48,190
handbook 5 you'll find that it's based

867
00:44:55,500 --> 00:44:51,540
on two-tenths of a percent permanent set

868
00:44:57,140 --> 00:44:55,510
because you don't know the track yield

869
00:44:59,640 --> 00:44:57,150
unless you have the thing on a machine

870
00:45:03,030 --> 00:44:59,650
until after you've exceeded it because

871
00:45:07,080 --> 00:45:03,040
you're still going up on your elasticity

872
00:45:09,089 --> 00:45:07,090
curve and until you pick out from the

873
00:45:13,470 --> 00:45:09,099
straight line you don't know you're

874
00:45:16,140 --> 00:45:13,480
above yield so as I mentioned earlier

875
00:45:18,599 --> 00:45:16,150
the the usual reason for going up close

876
00:45:22,710 --> 00:45:18,609
to the yield is to minimize the fatigue

877
00:45:24,570 --> 00:45:22,720
effects on fasteners but unless you have

878
00:45:26,580 --> 00:45:24,580
done an awful lot of testing it's not a

879
00:45:36,050 --> 00:45:26,590
good idea to go up to the yield point on

880
00:45:39,890 --> 00:45:36,060
a faster now on joint stiffness we have

881
00:45:42,300 --> 00:45:39,900
alluded to it many times up to now and

882
00:45:44,579 --> 00:45:42,310
and we covered the joint loading

883
00:45:46,320 --> 00:45:44,589
diagrams and now we look just look at

884
00:45:51,300 --> 00:45:46,330
the joint itself as we tighten the

885
00:45:54,510 --> 00:45:51,310
fasteners John Bickford actually has

886
00:45:55,980 --> 00:45:54,520
used a spring type analogy on this which

887
00:45:58,200 --> 00:45:55,990
makes it easier to understand because

888
00:45:59,730 --> 00:45:58,210

you take a piece here that has three

889
00:46:01,530 --> 00:45:59,740
different cross sections it's three

890
00:46:04,290 --> 00:46:01,540
different Springs with the three

891
00:46:07,650 --> 00:46:04,300
different spring constants and so you

892
00:46:18,710 --> 00:46:07,660
can think of a joint or a fastener that

893
00:46:26,900 --> 00:46:18,720
way and here is another one with the

894
00:46:37,219 --> 00:46:31,410
next page I thought I thought we'd had a

895
00:46:40,349 --> 00:46:37,229
stop a glitch during things okay alright

896
00:46:41,849 --> 00:46:40,359
well so the alright that this one's 101

897
00:46:45,479 --> 00:46:41,859
but just leave that not for anyway

898
00:46:48,749 --> 00:46:45,489
here is here's another thing that kind

899
00:46:51,269 --> 00:46:48,759
of shows you here the concept again of a

900
00:46:53,579 --> 00:46:51,279
large spring representing the joint and

901
00:46:55,049 --> 00:46:53,589
a fasteners a little little tiny spring

902
00:46:59,670 --> 00:46:55,059
that's trying to compress the big one

903
00:47:02,309 --> 00:46:59,680
and of course do keep the fasteners out

904
00:47:05,190 --> 00:47:02,319
of trouble you want their stiffness

905
00:47:07,829 --> 00:47:05,200
ratio to to the joint to be a pretty

906
00:47:09,779 --> 00:47:07,839
large differential and there's there's

907
00:47:11,130 --> 00:47:09,789
just showing clamping force all right

908
00:47:13,469 --> 00:47:11,140
now you can leave yours up over there

909
00:47:17,039 --> 00:47:13,479
and we'll go to the next one here and

910
00:47:22,279 --> 00:47:17,049
which we look at a boat remember in

911
00:47:27,509 --> 00:47:22,289
school you had calculating the expansion

912
00:47:29,940 --> 00:47:27,519
our tensile elongation on a rod and the

913
00:47:33,509 --> 00:47:29,950

Delta L or change in length was just PL

914
00:47:37,140 --> 00:47:33,519
over AE where P is the axial load ELLs

915
00:47:39,059 --> 00:47:37,150
of the elastic length and a is the rock

916
00:47:43,849 --> 00:47:39,069
cross-section and ease the modulus of

917
00:47:48,569 --> 00:47:43,859
elasticity and so if you apply this to a

918
00:47:51,299 --> 00:47:48,579
a bolt you can calculate these Delta

919
00:47:53,309 --> 00:47:51,309
ELLs for different cross sections and

920
00:47:57,059 --> 00:47:53,319
their lengths and John Bickford uses an

921
00:47:58,680 --> 00:47:57,069
extreme here on the next page in which

922
00:48:01,489 --> 00:47:58,690
he took a bolt that had been machined

923
00:48:06,359 --> 00:48:01,499
all over the place and he calculated a

924
00:48:09,959 --> 00:48:06,369
delta L based on all these different L

925
00:48:13,589 --> 00:48:09,969
over a ratios since since P and E are

926
00:48:17,519 --> 00:48:13,599
constant so that that is how you can

927
00:48:20,670 --> 00:48:17,529
arrive at a joint stiffness value for

928
00:48:22,259 --> 00:48:20,680
the bolt now I mean the stiffness from

929
00:48:25,799 --> 00:48:22,269
the bolt but now when you go to the

930
00:48:29,999 --> 00:48:25,809
joint there's where the authors disagree

931
00:48:33,150 --> 00:48:30,009
and there's all sorts of things so here

932
00:48:35,900 --> 00:48:33,160
are three different types of models if

933
00:48:37,920 --> 00:48:35,910
you will that are used to calculate

934
00:48:41,250 --> 00:48:37,930
joint stiffness

935
00:48:44,120 --> 00:48:41,260
the spear although it was listed I

936
00:48:46,950 --> 00:48:44,130
couldn't find any equations for it the

937
00:48:51,570 --> 00:48:46,960
cylinder is used a lot and the cone is

938
00:48:53,490 --> 00:48:51,580

used a lot and there are various ways of

939
00:48:55,200 --> 00:48:53,500
calculating the stiffness now what I'm

940
00:48:58,050 --> 00:48:55,210
talking about is if you look at these

941
00:49:06,740 --> 00:48:58,060
the hole here represents the hole where

942
00:49:10,050 --> 00:49:06,750
the bolt would go through okay

943
00:49:12,690 --> 00:49:10,060
now john Bickford uses the cylindrical

944
00:49:15,330 --> 00:49:12,700
model with a modification for eccentric

945
00:49:19,050 --> 00:49:15,340
loading at or near the edge of the joint

946
00:49:23,340 --> 00:49:19,060
and that is if you are wanting to use a

947
00:49:28,110 --> 00:49:23,350
circle and the bolt is close enough to

948
00:49:29,940 --> 00:49:28,120
the edge that you can't get the diameter

949
00:49:31,830 --> 00:49:29,950
circle you want you can put in a fudge

950
00:49:34,800 --> 00:49:31,840
factor for the fact that you're closer

951
00:49:39,240 --> 00:49:34,810
to the edge then you should be and this

952
00:49:41,160 --> 00:49:39,250
brings up another standard which is used

953
00:49:43,680 --> 00:49:41,170
a lot in the industrial world but

954
00:49:48,060 --> 00:49:43,690
difficult to obtain so I found out is

955
00:49:51,570 --> 00:49:48,070
the German standard Vern Dutch your

956
00:49:54,240 --> 00:49:51,580
engineer or other otherwise known as VDI

957
00:49:56,940 --> 00:49:54,250
since nobody could pronounce it that is

958
00:49:59,010 --> 00:49:56,950
a standard for doing calculations on

959
00:50:01,170 --> 00:49:59,020
fasteners that are loading the joint

960
00:50:06,570 --> 00:50:01,180
stiffness and all that type of thing and

961
00:50:07,680 --> 00:50:06,580
I have a copy of it but I had to get it

962
00:50:11,810 --> 00:50:07,690
through the back door because the

963
00:50:18,000 --> 00:50:15,210

sigelei who wrote a lot of books on

964
00:50:20,820 --> 00:50:18,010
engineering uses the cone frustum model

965
00:50:23,310 --> 00:50:20,830
with a cone angle 45 degrees measured

966
00:50:25,920 --> 00:50:23,320
from the bolt center line and then nasa

967
00:50:27,210 --> 00:50:25,930
langley had had another set up using a

968
00:50:29,220 --> 00:50:27,220
straight cylinder with three different

969
00:50:31,710 --> 00:50:29,230
equations depending on the minimum edge

970
00:50:36,780 --> 00:50:31,720
distance of the shortest side of the

971
00:50:42,720 --> 00:50:36,790
joint then another guy of the name of

972
00:50:45,150 --> 00:50:42,730
alexander blake uses a cone angle with

973
00:50:49,070 --> 00:50:45,160
angle determined by a line drawn from

974
00:50:51,660 --> 00:50:49,080
the outer edge of the flat of the head

975
00:50:54,270 --> 00:50:51,670
to the centerline of the clamp

976
00:50:56,730 --> 00:50:54,280
joint so this is the clamp joint here to

977
00:51:01,950 --> 00:50:56,740
here and there's a centerline but for

978
00:51:06,270 --> 00:51:01,960
the cone comes to and then using all of

979
00:51:13,049 --> 00:51:06,280
this stuff all of these measurements to

980
00:51:16,049 --> 00:51:13,059
calculate a joint stiffness and he comes

981
00:51:21,480 --> 00:51:16,059
up with a nice nice little equation here

982
00:51:23,640 --> 00:51:21,490
and this is for a particular angle of 45

983
00:51:26,490 --> 00:51:23,650
degrees I believe here no I'm sorry this

984
00:51:27,569 --> 00:51:26,500
is the shig Lee method on the cone we

985
00:51:30,450 --> 00:51:27,579
have the other one I guess in the

986
00:51:32,819 --> 00:51:30,460
appendix but you can have you have an

987
00:51:35,069 --> 00:51:32,829
equation there that you can use to

988
00:51:36,539 --> 00:51:35,079

calculate the joint stiffness so that

989
00:51:38,579 --> 00:51:36,549
you can compare it to your fastener

990
00:51:45,150 --> 00:51:38,589
stiffness to decide whether you're in

991
00:51:49,200 --> 00:51:45,160
trouble or not now as far as the joint

992
00:51:52,500 --> 00:51:49,210
stiffness calculations go here's one of

993
00:51:54,630 --> 00:51:52,510
the bad parts about it the affect of

994
00:51:56,609 --> 00:51:54,640
adjacent fasteners on joint compression

995
00:52:02,130 --> 00:51:56,619
is not accounted for in any of these so

996
00:52:05,180 --> 00:52:02,140
these are all empirical and the there

997
00:52:07,680 --> 00:52:05,190
they're only an indicator then

998
00:52:09,780 --> 00:52:07,690
unsymmetrical loading under a fastener

999
00:52:11,130 --> 00:52:09,790
due to edge distance or cutouts is not

1000
00:52:12,990 --> 00:52:11,140
accounted for in other words you're

1001
00:52:17,520 --> 00:52:13,000
using a perfect cone or a perfect

1002
00:52:21,120 --> 00:52:17,530
cylinder and then if the bolt and joint

1003
00:52:23,880 --> 00:52:21,130
materials are different the stiffness

1004
00:52:26,760 --> 00:52:23,890
calculations must account for the

1005
00:52:32,849 --> 00:52:26,770
different moduli of elasticity for the

1006
00:52:35,010 --> 00:52:32,859
materials now so so you're in in a

1007
00:52:40,730 --> 00:52:35,020
little bit of trouble there on getting

1008
00:52:43,680 --> 00:52:40,740
these however things could be worse here

1009
00:52:46,109 --> 00:52:43,690
are some of the things you can do first

1010
00:52:48,120 --> 00:52:46,119
try just a simple cylinder with a radius

1011
00:52:52,380 --> 00:52:48,130
equal to the shortest edge distance the

1012
00:52:54,930 --> 00:52:52,390
fasteners this is called the barrett

1013
00:52:57,890 --> 00:52:54,940

theory of least work don't do any more

1014
00:53:00,510 --> 00:52:57,900
than you have to to show something good

1015
00:53:02,970 --> 00:53:00,520
if this stiffness is satisfactory

1016
00:53:04,540 --> 00:53:02,980
compared to the fastener don't go any

1017
00:53:06,820 --> 00:53:04,550
further go with it

1018
00:53:09,460 --> 00:53:06,830
if the simple cylinder is not

1019
00:53:11,350 --> 00:53:09,470
satisfactory add a washer with a

1020
00:53:13,090 --> 00:53:11,360
diameter larger than the fastener head

1021
00:53:17,430 --> 00:53:13,100
to kind of spread out the radius on your

1022
00:53:19,930 --> 00:53:17,440
cylinder then check it for that and

1023
00:53:22,120 --> 00:53:19,940
check the compressive stress under the

1024
00:53:24,490 --> 00:53:22,130
head contact area to make sure that the

1025
00:53:30,400 --> 00:53:24,500
compressive yield will not occur under

1026
00:53:34,720 --> 00:53:30,410
the maximum clamping load and then if

1027
00:53:38,820 --> 00:53:34,730
all else fails go do the calculations if

1028
00:53:42,040 --> 00:53:38,830
it is critical enough now in most cases

1029
00:53:44,830 --> 00:53:42,050
you are not critical enough that you

1030
00:53:47,260 --> 00:53:44,840
would have to go to a lot of lengths on

1031
00:53:49,420 --> 00:53:47,270
the difference between the fastener

1032
00:53:52,420 --> 00:53:49,430
stiffness and joint stiffness only a

1033
00:53:54,730 --> 00:53:52,430
rare case is now one of the things that

1034
00:54:00,730 --> 00:53:54,740
you want to be aware of is don't use a

1035
00:54:02,890 --> 00:54:00,740
big fat fastener on a thin joint because

1036
00:54:04,390 --> 00:54:02,900
chances are then the fastener is going

1037
00:54:07,510 --> 00:54:04,400
to be stiffer than the joint and you're

1038
00:54:09,880 --> 00:54:07,520

gonna have trouble you've been in

1039
00:54:12,940 --> 00:54:09,890
trouble on it but you can you can check

1040
00:54:15,790 --> 00:54:12,950
them and see what you've got and if if

1041
00:54:17,890 --> 00:54:15,800
your ratio is not too bad even for

1042
00:54:20,860 --> 00:54:17,900
taking that short cut method say 5 or

1043
00:54:25,540 --> 00:54:20,870
something between fastener and joint go

1044
00:54:27,900 --> 00:54:25,550
with it and it should be alright now

1045
00:54:30,370 --> 00:54:27,910
indirect reading of fastener tension

1046
00:54:32,380 --> 00:54:30,380
this question is asked how can I

1047
00:54:33,790 --> 00:54:32,390
determine the exact tension I have on a

1048
00:54:38,020 --> 00:54:33,800
fastener for a given torque

1049
00:54:40,570 --> 00:54:38,030
well the direct reading is possible but

1050
00:54:43,690 --> 00:54:40,580
it's not economically feasible for most

1051
00:54:46,660 --> 00:54:43,700
assemblies the technology is there that

1052
00:54:50,440 --> 00:54:46,670
you can't afford it so the usual

1053
00:54:52,270 --> 00:54:50,450
compromise is to test fasteners under

1054
00:54:55,360 --> 00:54:52,280
the closest actual installation

1055
00:54:58,030 --> 00:54:55,370
conditions that you can come up with and

1056
00:54:59,980 --> 00:54:58,040
determine a torque value then use that

1057
00:55:03,580 --> 00:54:59,990
torque value for your production

1058
00:55:09,760 --> 00:55:03,590
assemblies and so we'll cover a couple

1059
00:55:13,390 --> 00:55:09,770
of the upper three here of the direct

1060
00:55:17,549 --> 00:55:13,400
tension measurements now this one an

1061
00:55:19,839 --> 00:55:17,559
ultrasonic that's a good one

1062
00:55:23,469 --> 00:55:19,849
transducers mounted to the head of the

1063
00:55:26,019 --> 00:55:23,479

boat but as the bullet elongates the

1064
00:55:28,089 --> 00:55:26,029
travel time for the sound you know the

1065
00:55:30,759 --> 00:55:28,099
way ultrasonics work you bounce it off

1066
00:55:32,829 --> 00:55:30,769
of the back surface and back so if you

1067
00:55:35,829 --> 00:55:32,839
increase the length of the thing it

1068
00:55:38,229 --> 00:55:35,839
takes longer for thee for the ultrasonic

1069
00:55:40,329 --> 00:55:38,239
wave to get there and back so that is a

1070
00:55:42,700 --> 00:55:40,339
you can get a direct correlation between

1071
00:55:44,319 --> 00:55:42,710
the elongation of the boat which knowing

1072
00:55:48,999 --> 00:55:44,329
the cross-sectional area will give you

1073
00:55:52,539 --> 00:55:49,009
the stress well that's a very good thing

1074
00:55:54,009 --> 00:55:52,549
but the major drawback to it is you've

1075
00:55:56,620 --> 00:55:54,019
got to have the smooth surface to attach

1076
00:56:00,640 --> 00:55:56,630
it to because if you remember even if

1077
00:56:02,170 --> 00:56:00,650
you go in and have your heart checked or

1078
00:56:05,380 --> 00:56:02,180
something like that that they use an

1079
00:56:08,200 --> 00:56:05,390
ultrasonic fluid that they put on on

1080
00:56:10,630 --> 00:56:08,210
your body so that because you've got to

1081
00:56:12,279 --> 00:56:10,640
have a medium for it to go through so

1082
00:56:15,069 --> 00:56:12,289
you have to have a nice smooth surface

1083
00:56:17,319 --> 00:56:15,079
and then you have to have some sort of a

1084
00:56:22,089 --> 00:56:17,329
gel on there to put your transducer on

1085
00:56:23,979 --> 00:56:22,099
get it to hold so now what do you do if

1086
00:56:28,319 --> 00:56:23,989
you got a socket head Bowl you don't

1087
00:56:34,509 --> 00:56:31,479
then once the bolt is calibrated for a

1088
00:56:36,339 --> 00:56:34,519

zero load you have to disconnect the

1089
00:56:37,930 --> 00:56:36,349
transducer in order to Terk the bolt

1090
00:56:40,690 --> 00:56:37,940
down to the load you want so that you

1091
00:56:43,870 --> 00:56:40,700
can measure it again so this one is is a

1092
00:56:51,299 --> 00:56:43,880
good method but it's not really

1093
00:56:57,519 --> 00:56:55,599
neck next one is direct scaling now that

1094
00:56:59,920 --> 00:56:57,529
we had mentioned that earlier in which

1095
00:57:02,049 --> 00:56:59,930
where both ends of the installed bolt

1096
00:57:03,759 --> 00:57:02,059
are accessible such as pipe flange you

1097
00:57:05,890 --> 00:57:03,769
can actually measure the bolt and

1098
00:57:10,180 --> 00:57:05,900
subtract out the dead areas that are on

1099
00:57:12,670 --> 00:57:10,190
the the outside of the nut the heads and

1100
00:57:16,539 --> 00:57:12,680
so on and use the elongation there of

1101
00:57:18,579 --> 00:57:16,549
the boat to arrive at a load then of

1102
00:57:21,249 --> 00:57:18,589
course these direct tension indicating

1103
00:57:24,789 --> 00:57:21,259
washers that we covered in the washer

1104
00:57:26,559 --> 00:57:24,799
section those are used successfully in

1105
00:57:28,839 --> 00:57:26,569
the construction business because you

1106
00:57:30,850 --> 00:57:28,849
take a feeler gauge and inspect keep

1107
00:57:37,980 --> 00:57:30,860
talking until you get a gap of a certain

1108
00:57:45,430 --> 00:57:42,340
then we have this test machine by Ralph

1109
00:57:48,520 --> 00:57:45,440
shoberg of RS Technologies Farmington

1110
00:57:52,090 --> 00:57:48,530
Hills Michigan aides are one of my

1111
00:57:55,960 --> 00:57:52,100
fellow compadres on the lecture circuit

1112
00:57:57,460 --> 00:57:55,970
on fasteners and he has a machine that

1113
00:58:01,180 --> 00:57:57,470

will actually you can throw a bolt in it

1114
00:58:03,910 --> 00:58:01,190
and it will tell you for a given bolt

1115
00:58:07,030 --> 00:58:03,920
the exact amount that you have

1116
00:58:09,400 --> 00:58:07,040
pretension the exact amount for head

1117
00:58:12,700 --> 00:58:09,410
friction the exact amount for nut

1118
00:58:15,040 --> 00:58:12,710
friction but the only thing is it'll

1119
00:58:16,540 --> 00:58:15,050
tell you for that bolt it won't tell you

1120
00:58:19,180 --> 00:58:16,550
about your total installation so what

1121
00:58:22,990 --> 00:58:19,190
you have to do is take a bolt that

1122
00:58:24,850 --> 00:58:23,000
you're going to use and decide what you

1123
00:58:27,010 --> 00:58:24,860
want to load it to put it in the machine

1124
00:58:29,020 --> 00:58:27,020
and determine what perk it takes to give

1125
00:58:32,800 --> 00:58:29,030
you that stress and then use that for