TALAT Lecture 2102.01

A Floodlight for an Offshore Oil Platform

22 pages, 30 figures
Basic Level

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Objectives:
This chapter offers an example of product development. The goals are:
To impart knowledge about:

- the design possibilities inherent in aluminium sections
- the choice of alloy.

To give insight into:

- how to develop a product using the general specificiations and the interaction between form, material and processing chain
- the importance of being thoroughly familiar with the different design materials, their processing possibilities and properties.

Prerequisites:
The lecture is recommended for those situations, where a brief, general background information about aluminium is needed as an introduction of other subject areas of aluminium application technologies.

This lecture is part of the self-contained course „Aluminium in Product Development“ which is treated under TALAT lectures 2101 and 2102. It was originally developed by Skanaluminium, Oslo, and is reproduced for TALAT with kind permission of Skanaluminium. The translation from Norwegian into English was funded within the TALAT project.

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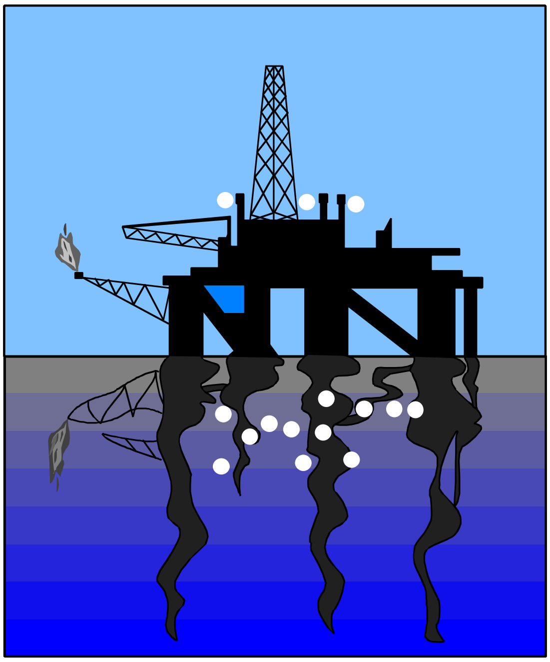
2102.01 A Floodlight for an Offshore Oil Platform

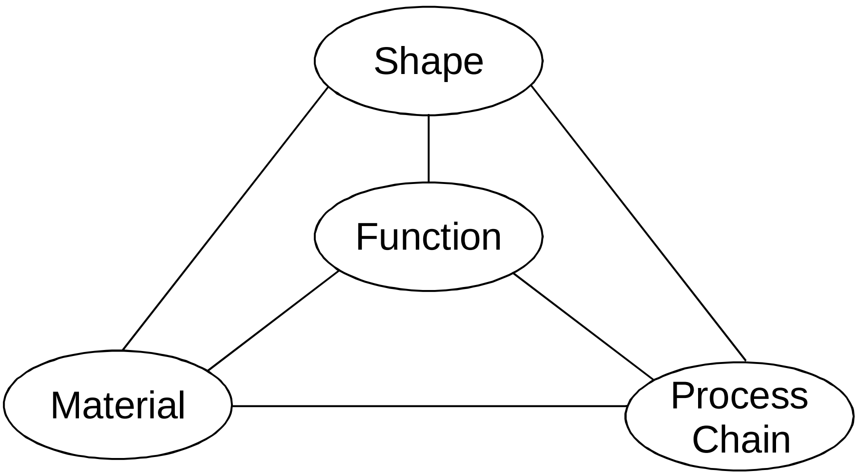
Introduction

Offshore applications require lights (see **Figure 2102.01.01**)that can be easily moved and set up on site, wherever specific jobs are to be performed. Very stringent requirements apply to electrical appliances for use in areas where there could be danger of explosion. This lighting system will be used in areas classified as zone 1, i.e., areas occasionally exposed to explosive pressures under normal operating conditions.



Floodlight Offshore 2102.01.01

This chapter deals with a complex, relatively intricate product, so we have no choice but to limit and simplify our review of the product development process (**Figure 2102.01.02**).



An Important Interaction 2102.01.02

Basic Specification

Based on this figure, we will begin by undertaking a functional analysis of the light source (**Figure 2102.01.03**):

Main Function

- To Provide Working Light

TALAT	Main Function	2102.01.03

The requirements that apply to the lamp (see **Figure 2102.01.04**) are derived from prevailing standards, the company, the customer and the relavant operating conditions.

The last four requirements cannot be answered with an immediate yes or no by simply looking at a solution. Consequently, we must define which faults or damages we can accept within the constraints of these requirements. The safety requirements are comprehensive. **Figure 2102.01.05** provides an excerpt of them.

Requirements

- Satisfy Safety Standards
- Halogen Lamp as a Light Source
- Small Series with Luminous Intensities Ranging from 300 W to 3000 W
- Withstand Winds of up to 200 km/ h
- Withstand Temperatures between -7° C and +150° C
- Be Corrosion-Resistant in Saline Environment
- Last for at Least 10 Years

TALAT	Requirements	2102.01.04

Safety Requirements for Appliances Designated for use in Explosive areas

Electrical Equipment:

- The light shall have a transparent cover, attached by clamps and with approved packing material
- The lamp casing shall be able to withstand internal explosion
- Material standard for light metals: Mg < 6%
- Material standard for plastic:
  The highest temperature of the lamp shall be at least 20 °C less than the temperature which results in a 50% reduction in flexural resistance after 20.000 hours of exposure
- The finished product shall undergo a testing programme

Installation:

- Placement at least 20 m from the work site

TALAT Training in Aluminium Application Technologies	Safety Requirements for Appliances Designated for Use in Explosive Areas	2102.01.05

The properties that denote a good lamp solution are as shown in **Figure 2102.01.06**.

Properties

- Low Weight
- Simple, Reliable Operation
  - Be Simple and Easy to Assemble
  - Require Minimum Maintenance
  - Easy to Replace Source of Light
- Low Production Costs
  - Low Production Equipment Costs (Small Runs)

TALAT Training in Aluminium Application Technologies	Properties	2102.01.06

Not all such properties are equally important. For our purposes, it is sufficient to think in fairly general, qualitative terms: Low production costs and simple, reliable operation should be given high priority.

Possible Solution Concepts

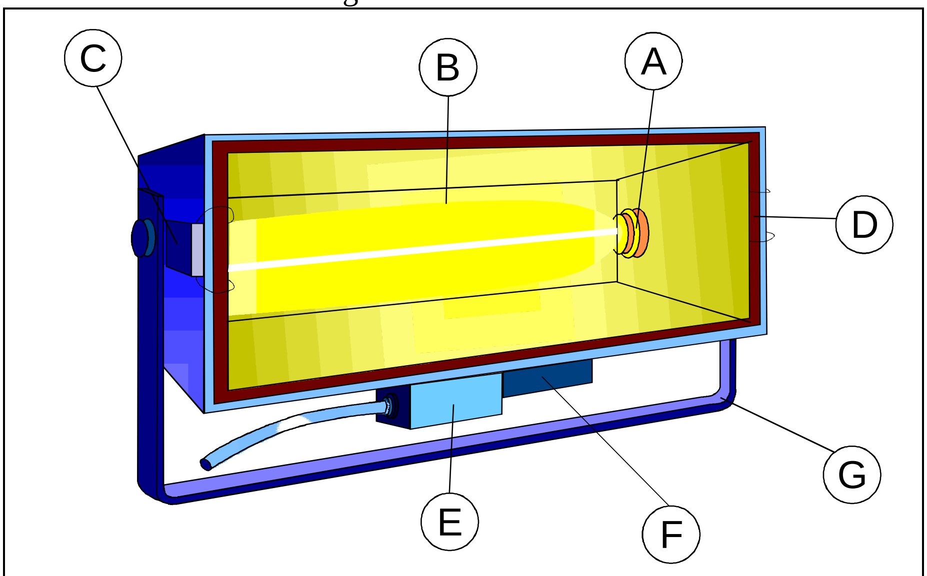
At this point, we are still operating at a highly abstract level which affords us the opportunity to keep all our options open. It is important to spend some time on this early phase in order to prevent valuable solution concepts from being lost later on in the process.

Nonetheless, the stringent requirements laid down by the authorities and the customer clearly limit our freedom of design. Not least the customer's requirement that the source of light be a halogen lamp calls various designs to mind immediately. **Figure 2102.01.07** illustrates one potential solution that meets our initial specifications.

Functions at the Next Level

Based on this concept, we can set up functional requirements for the next step in the product development process. We shall expand our original functional requirement to "provide working light" to: (see **Figure 2102.01.07**)

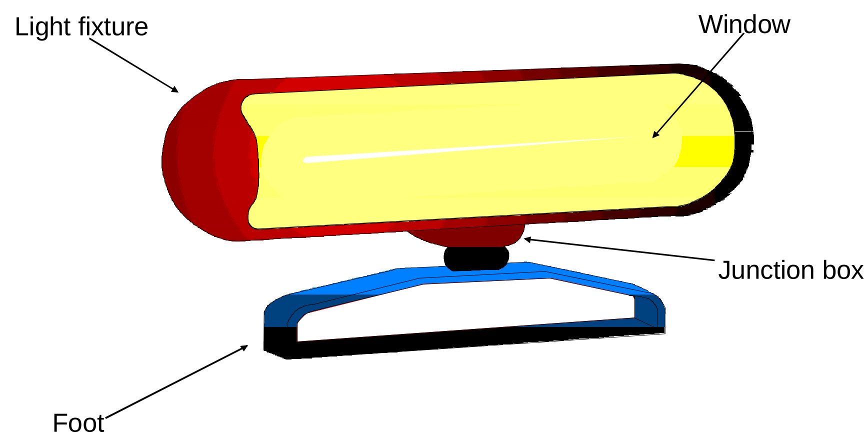
A Connect power
B Focus light
C Seal out the outside environment
D Provide access to the light source
E Receive power
F Carry power
G Position the floodlight



TALAT | Example of a Floodlight | 2102.01.07

At this point, it might be expedient to divide the product up into its component parts. For the time being, we will divide it into four parts (see **Figure 2102.01.08**):

- the light fixture
- window
- junction box
- foot.



TALAT | Example of a Floodlight | 2102.01.08

The Light Fixture - Material, Process and Form

We will begin with the light fixture, to which the following functional requirements apply (see **Figure 2102.01.09)**:

Functions of the Light Fixture

- Hold the halogen lamp
- Focus the light
- Support the window, junction box and foot

TALAT | Functions of the Light Fixture | 2102.01.09

Refer to **Figure 2102.01.02** once again. In the following discussion, we will use pictures to illustrate how the relationship between form, material and production method is related to the further evaluation of solutions.

Possible Solution Concepts

We will review three different materials: steel, plastic and aluminium.

Figure 2102.01.10 shows one design possibility if we were to choose stainless steel. The natural choice of process would be deep-drawing. The solution would require expensive tooling, so it would work best with large runs. Such a solution would also make it difficult to install the junction box.

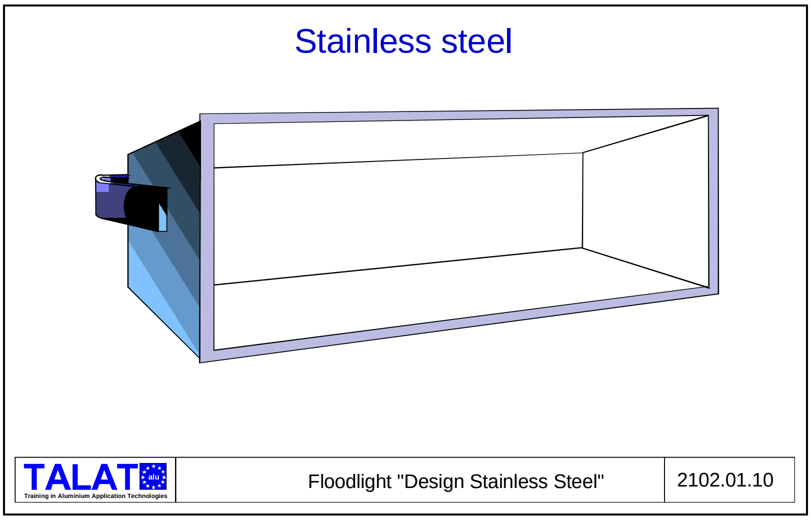
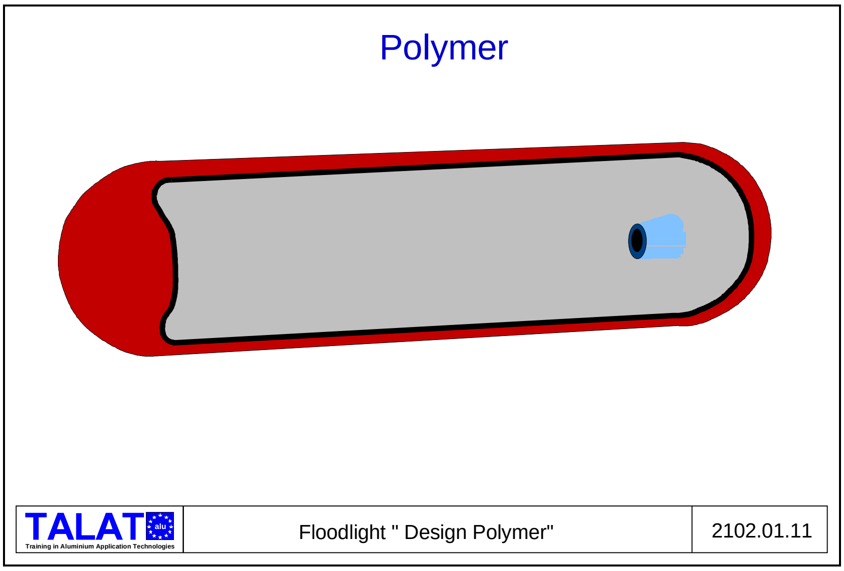
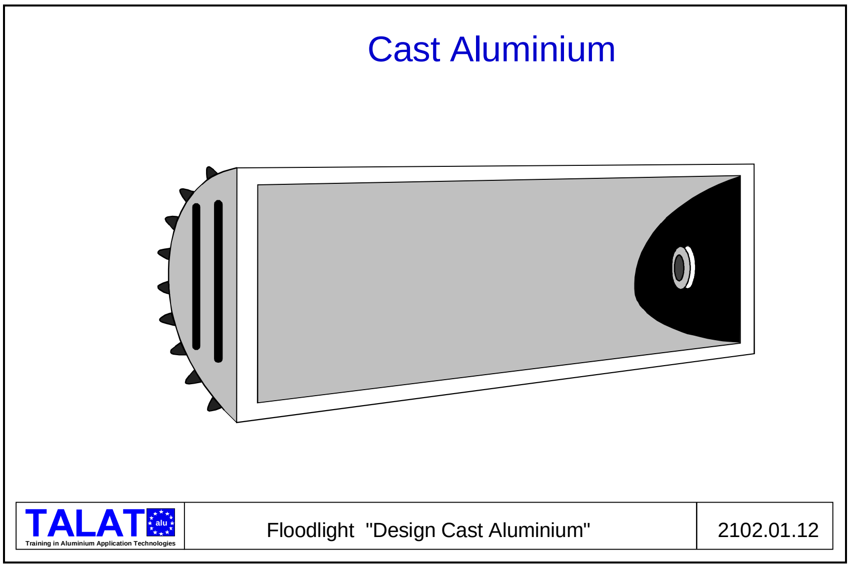


Figure 2102.01.11 illustrates a design that might work in GUP, glassfibre-reinforced unsaturated polyester. The material would enable us to select injection moulding, but the tooling is expensive and once again dependent on large runs. Furthermore, the plastic would become too soft when the temperature approaches 150 °C. Cooling would be difficult.

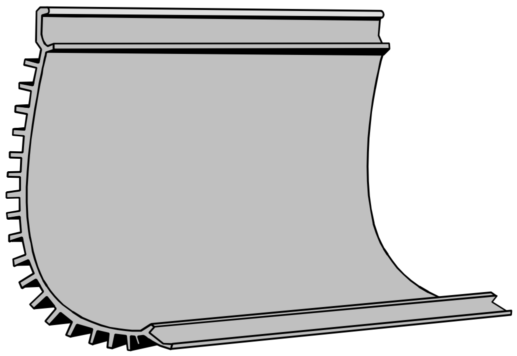


In **Figure 2102.01.12** we see a potential design in cast aluminium. We have incorporated cooling fins into the mould. Tooling is a major expense with this method as well. A solution in cast aluminium would also be rather heavy.

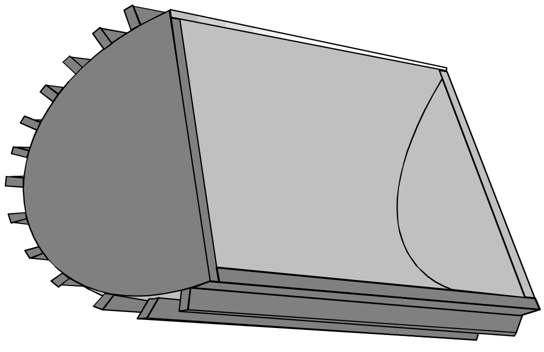


It is obvious that plastic is not very appropriate because of the temperature requirement. On the other hand, both steel and aluminium fulfil the requirements. The only problem is that the solutions would both probably turn out to be very costly. Can we find a better solution?

A comparison of the three proposals shows they are all dependent on expensive tooling, a factor which limits our chances of making the light fixture in a variety of different lengths. Can we circumvent the problem?



Would it be possible to use aluminium extrusions? Such a solution would leave us without end brackets. Can that be rectified? Another look at the solution in cast aluminium shows that the end brackets could all be alike, since their shape is entirely independent of the length of the fixture (**Figure 2102.01.13**). Would it be possible to combine a cast solution with an extruded solution to take maximum advantage of the benefits offered by both fabrication methods? Casting allows us to make a three-dimensional shape, but calls for expensive tooling and is thus most cost-efficient with large runs. Aluminium extrusions are long segments of two-dimensional cross-sections that can be divided up into the desired lengths.



Let us move on to explore whether it might be possible to make a light fixture based on aluminium extrusions and cast-aluminium end brackets (see **Figure 2102.01.14**).

For this purpose, we decide to examine the aluminium extrusion solution more closely (aluminium casting is discussed in TALAT lecture 2102.03)). The designer may want to consult an extrusion expert for help as regards the use of extruded sections.

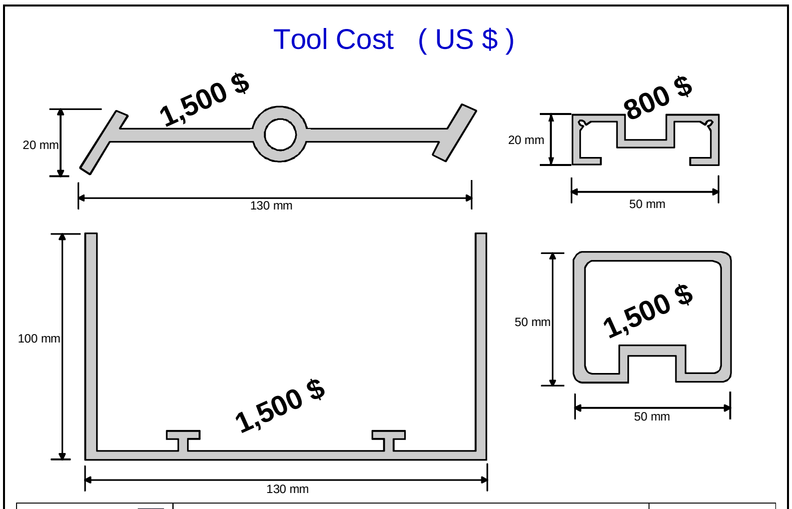
At this point of the case study it is worthwile to consider the design characteristics of extrusion in some greater detail, as outlined below.

SPECIAL STUDY: Extruding Aluminium

Extrusion Tools

Figure 2102.01.15 *gives some examples of tooling costs, which usually run from US $ 800 to US $ 5,000. This means tooling can be crafted fairly early on in the process, and a few metres of sections can be extruded for use in prototypes. Minor adjustments can be made later if necessary. The point is that no major investment will be lost if the result is unsuccessful.*

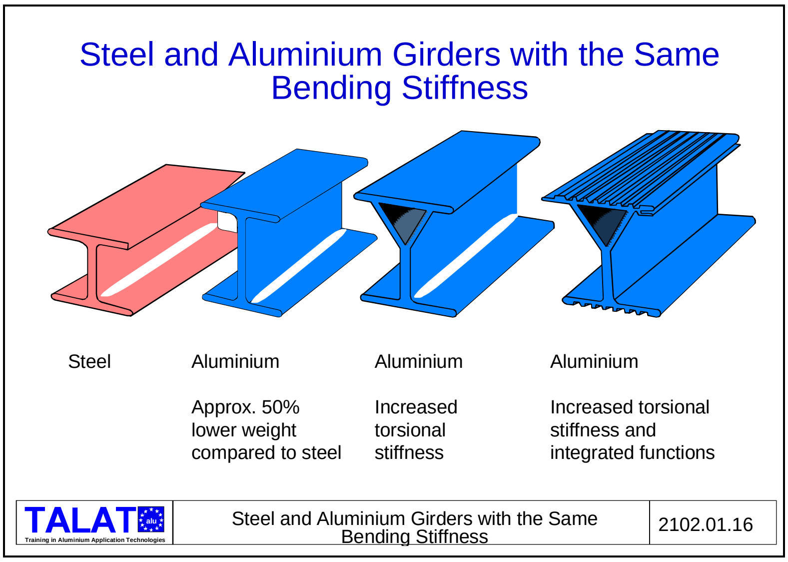
We distinguish between solid and hollow sections with one or more hollows. A hollow extrusion tool is more complicated than a tool for solid sections, so it will be slightly more expensive to make.



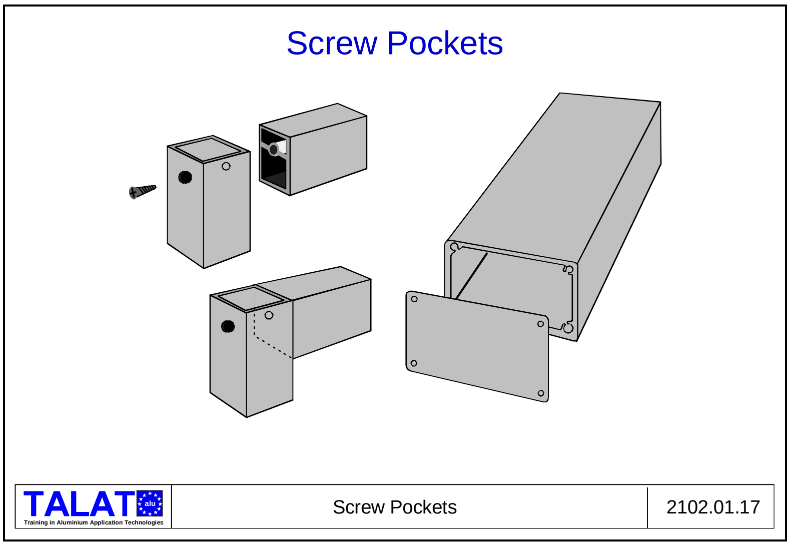
Example of Tool Costs for Extrusions 2102.01.15

Examples of Extruded Aluminium Solutions

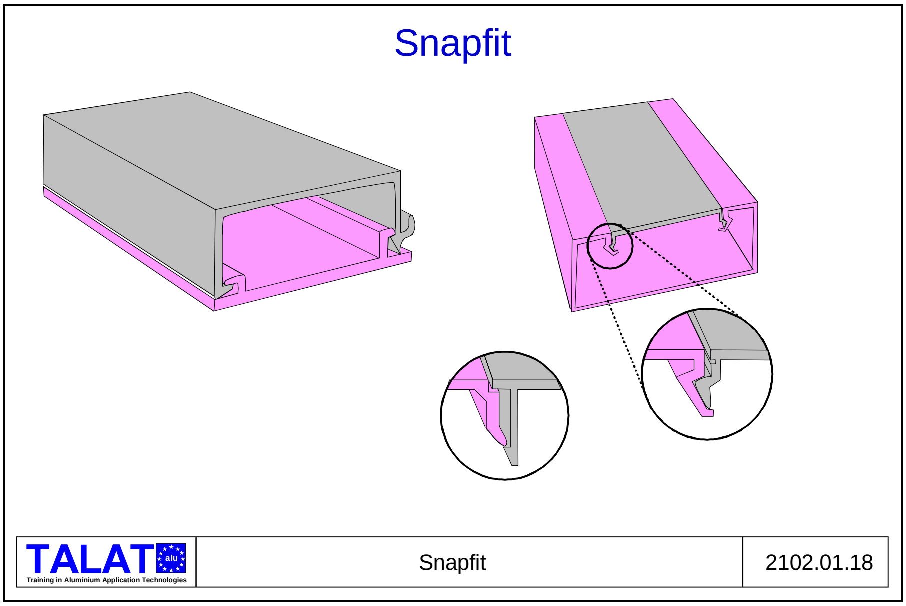
When designing extrusions, the designer is generally free to decide how he wants to distribute the material. For example, when making a load-bearing girder, the designer would want to concentrate the material in the areas of the cross-section where it would *be most effective. **Figure 2102.01.16** compares a steel girder with an aluminium girder. Note that the two have the same bending stiffness. This was achieved by increasing the depth of the rib in the aluminium girder. In this case, switching from steel to aluminium resulted in a weight savings of roughly 50 per cent. Even greater savings can often be achieved by making more drastic changes in design when switching from steel to aluminium. For girders exposed to bending loads, a good rule of thumb is that aluminium usually weighs about half as much as steel. As the figure also shows, the girder can easily be made with more torsional stiffness and additional integrated functions.*



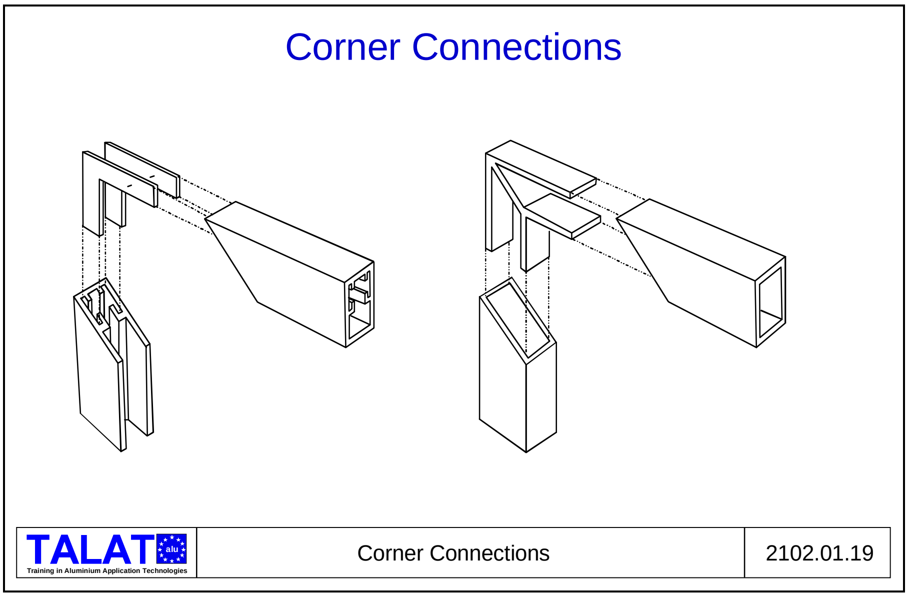
*One sound structural method for making corners involves the use of extruded screw pockets. The picture (**Figure 2102.01.17**) gives some examples. A groove has been incorporated into one of the extrusions. The opposite extrusion is equipped with a counter-groove so the two sections inter-lock. In other words, a firmly locked connection is achieved with just one self-tapping sheet metal screw, eliminating the need for drilling or tapping. This simplifies assembly and keeps costs down.*



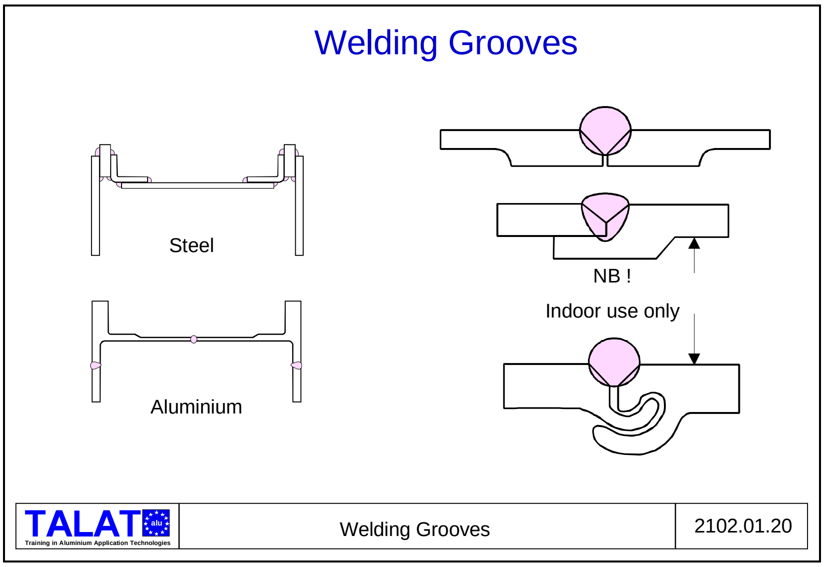
Another way to assemble extrusions is to take advantage of the excellent elasticity of aluminium. A simple cover is to be fitted to a channel (see ***Figure 2102.01.18)****. By constructing the channel as illustrated, the parts can be snapped together without using screws or any other form of fastener. Snap-fit solutions of this kind can be designed in a variety of ways, depending on whether or not they are to be re-openable.*



*Where fairly strong corner joints are required, we can use corner blocks of various kinds. Here (****Figure 2102.01.19****) is a solution in which the corner block is a short piece of a special extrusion. The chamfered extrusions are threaded on to this. Of course, corner extrusions can be designed in any number of ways, depending on what they are to be used for.Ordinary sheet metal angles may be good enough for a simple switchboard frame, for instance.*



*Substantial advantages may also be gained by thinking in terms of extrusions for welded items (**Figure 2102.01.20**).*



A proficient steel designer can build up a complex cross-section from standard elements. As in this case, however, such a process often involves numerous welds. Aluminium extrusions would increase the efficiency of this solution considerably. An extruded solution would entail only three welds, all of which could be conveniently located. The welds could also be positioned to ensure the same material thickness on both sides of the weld, which improves the result. No slots have to be cut since they can be incorporated into the design of the extrusion. Slots can be made in many ways, and several different light fixture designs come to mind even while the extrusion is still on the drawing board. In many cases, it is highly advantageous to substitute aluminium parts for steel parts simply because many of the preliminary operations can be eliminated.

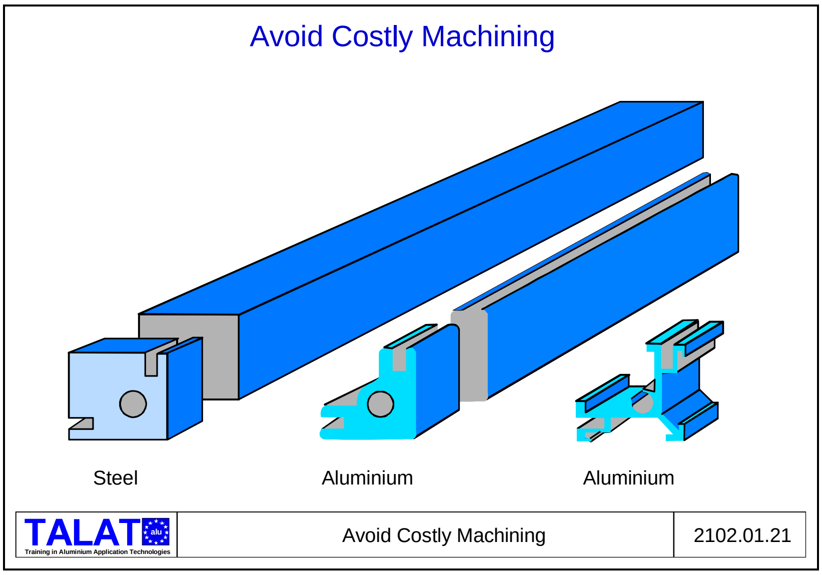


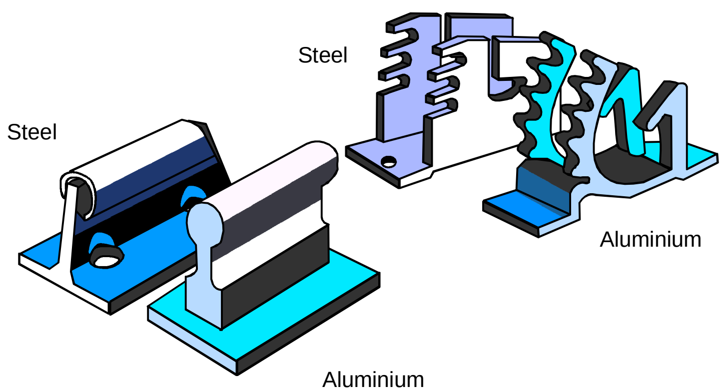
***Figure 2102.01.21** gives an example of one specific component which, when made of steel, is produced from steel bar which has to undergo several processing operations. When made of aluminium, it is directly extruded as an integral part of our final cross-section, then finished by simple processing.*

Learning to Think in Terms of Extrusions

The concept of thinking in terms of extrusions can be exemplified. The left side of the illustration shows a pedestal for sort of "rubber block" that Volvo uses to transport engines. Initially, the pedestal was made of steel, and it consisted of standard elements like a T-section and a tube. The resultant structure was not very satisfactory. Holes had to be drilled from underneath to secure the block. These holes, which had to be tapped, broke through the material of the flange. Extrusions can incorporate such details directly into the cross-section. The thickness of the material at the base of the flange has been increased, so the drill doesn't break through when the holes are drilled. Instead of splitting a tube, the extrusion incorporates a bead which prevents the rubber block from being pulled off its pedestal. A comparison of the costs of the two options shows that the aluminium solution costs less than half as much as the steel solution, thanks to the simplified production method.

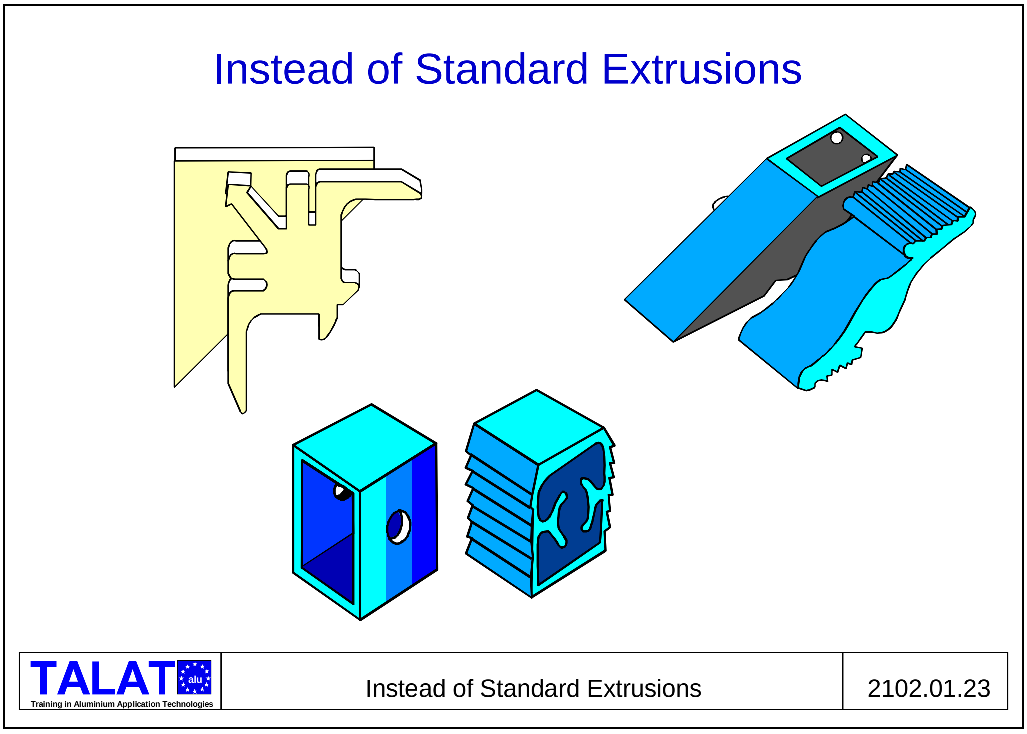
*The example on the right in Figure **2102.01.22** is a clamp for an anemometer (wind gauge) to be mounted on the masthead of a sailboat. The clamp has a pin attached at two points. The front point is to allow for adjustment in three different positions. A steel designer would usually begin with a piece of sheet metal which he would bend as shown in the illustration. With a touch of imagination, a similar item could be made from an aluminium extrusion. The extrusion could be cut and milled in a single operation, making extrusion a faster and more efficient way of incorporating this function into the component.*

Think in Terms of Extrusions



TALAT	Think in Terms of Extrusions	2102.01.22

Components are often based on standard extrusions such as tubes, rods and the like. ***Figure 2102.01.23*** *shows a wheelchair brake. One of its functions is to lock the wheels. Originally, the brake was made of a square-section extrusion, cut diagonally. The design required that a hole be punched through the centre of the section to accommodate the axle. A specially designed extrusion would be a more natural solution for this. The function could be incorporated into the cross-section, leaving nothing to do but the cutting.*



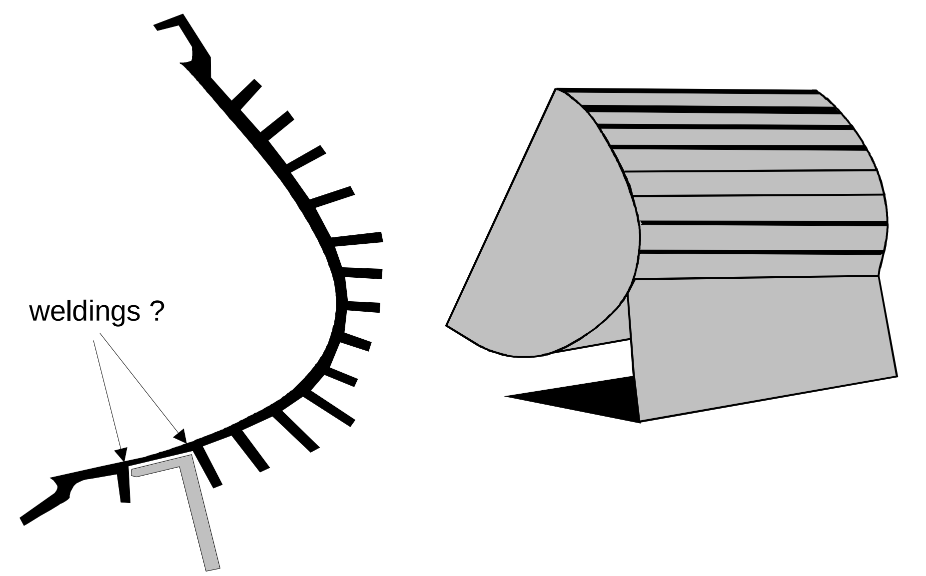
We return now to the next steps in the design of the floodlight.

The Next Step in Designing the Lighting Fixture

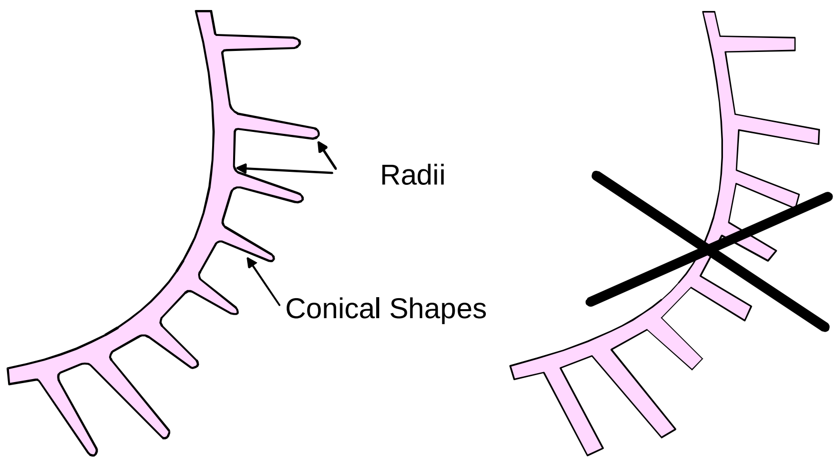
We shall now find out how we can use extrusion technology to arrive at an optimum design for the lamp.

Figure 2102.01.24 indicates one possible way of using an extrusion. The mounting bracket could be welded between two cooling fins. In cooperation with an extrusion expert, this solution is carried a step further (**Figure 2102.01.25**):

The extrusion expert proposes a few minor modifications of the cross-section to simplify the production of the extrusion. The cooling fins, originally drawn with sharp edges and at random, should have a softer, more rounded shape. The expert recommends rounding off all sharp angles and corners, then goes on to recommend a convex shape for the cooling fins. his offers an advantage as far as extruding is concerned and it doesn't reduce the fins' cooling effect. In other words, our design for the cooling fins has been improved, and it will ultimately result in a cheaper, better product.



TALAT	Design for Welding	2102.01.24

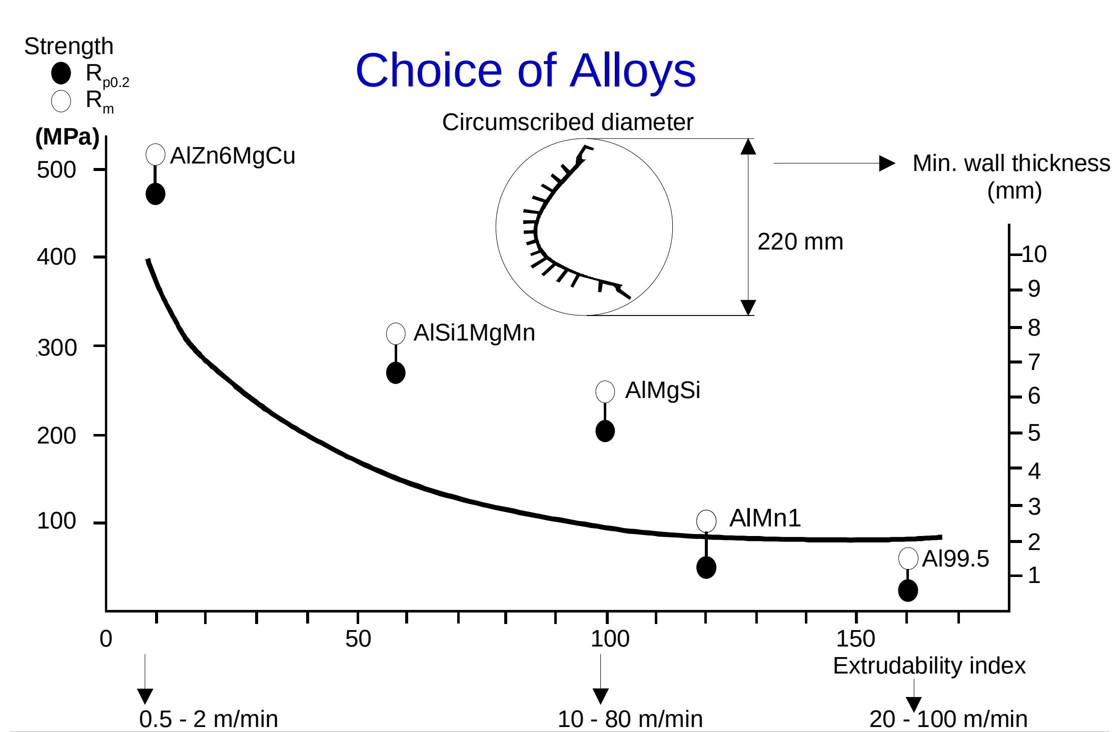


TALAT	Design of Extrusions	2102.01.25

Choice of Alloy

It is now time to choose our alloy. We must select one that is strong, yet malleable enough to facilitate the structural details and wall thicknesses we want. The minimum wall thickness that can be extruded depends on the extrusion cross-section, i.e., whether it is solid or hollow, as well as on the circumscribed diameter and the alloy.

Figure 2102.01.26 is made using extrudability data for a solid section with a circumscribed diameter of 220 mm. The axis at the left indicates strength and the axis at the right indicates minimum wall thickness.



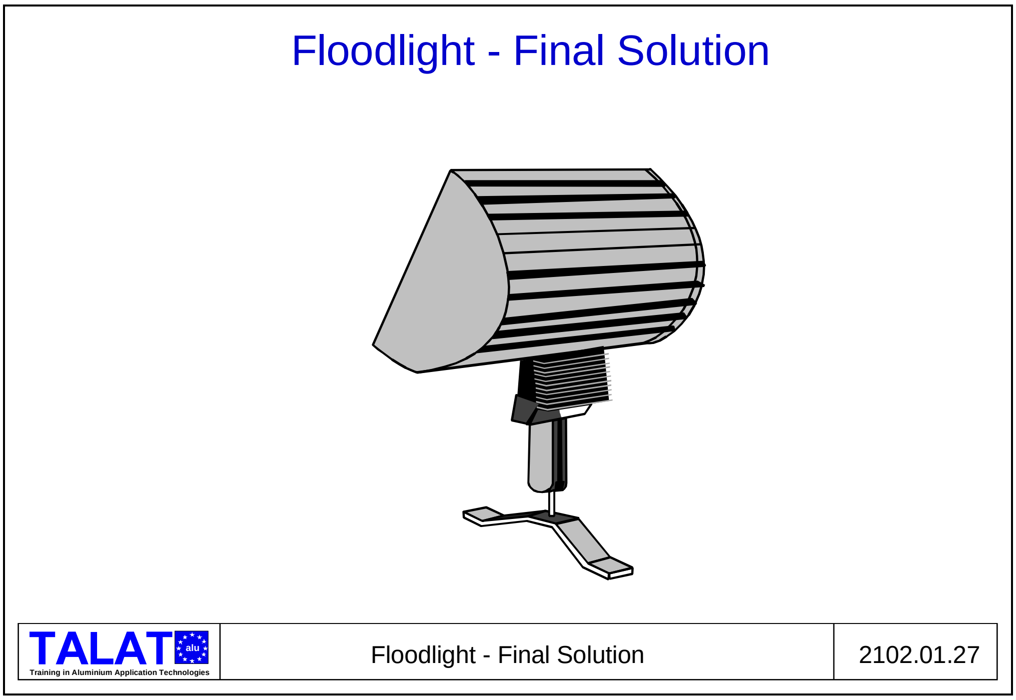
TALAT Training in Aluminium Application Technologies | Choice of alloys | 2102.01.26

We can see how extrusion speed is influenced by the choice of alloy. The same figure shows how the minimum wall thickness of an extrusion is also contingent on the choice of alloy. The curve indicates the minimum wall thickness. For instance, Al 99.5 has a minimum wall thickness of 2 mm, compared with 3.2 mm for AlSi1MgMn.

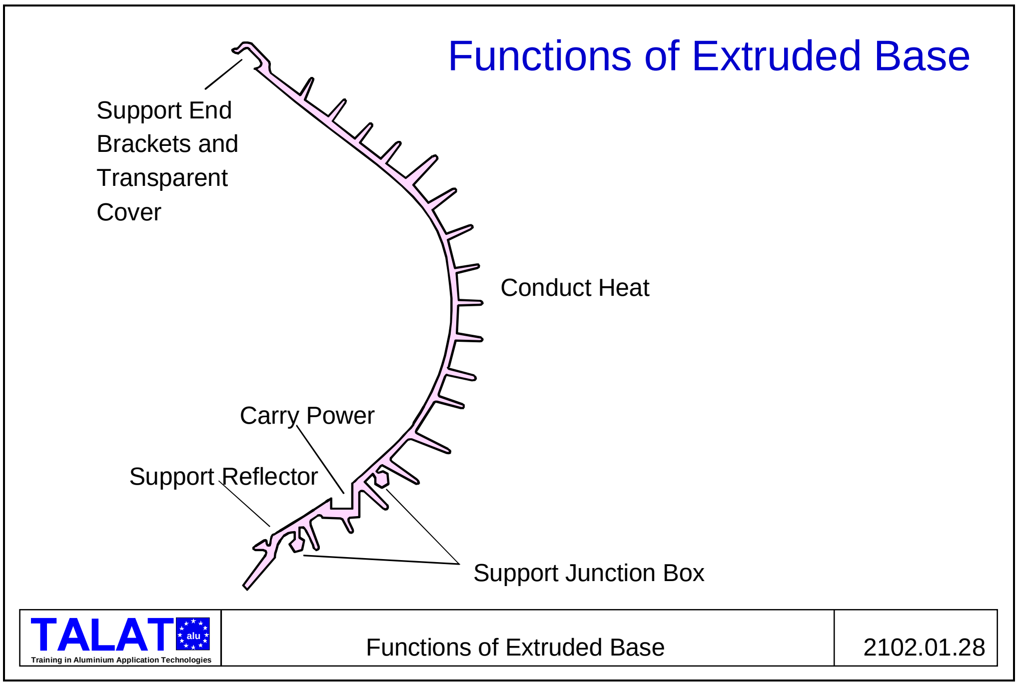
Alloys containing zinc and copper are very strong, but they are difficult to extrude and they cannot offer the details and wall thicknesses desired. Of the two remaining alloys, AlSi1MgMn and AlMgSi, we choose the latter. It has sufficient strength and is easier to extrude than the former. It is also sufficiently corrosion-resistant to withstand a saline environment. AlMgSi is actually the most widely used alloy for extruded sections.

The Final Step in Designing the Lighting Fixture

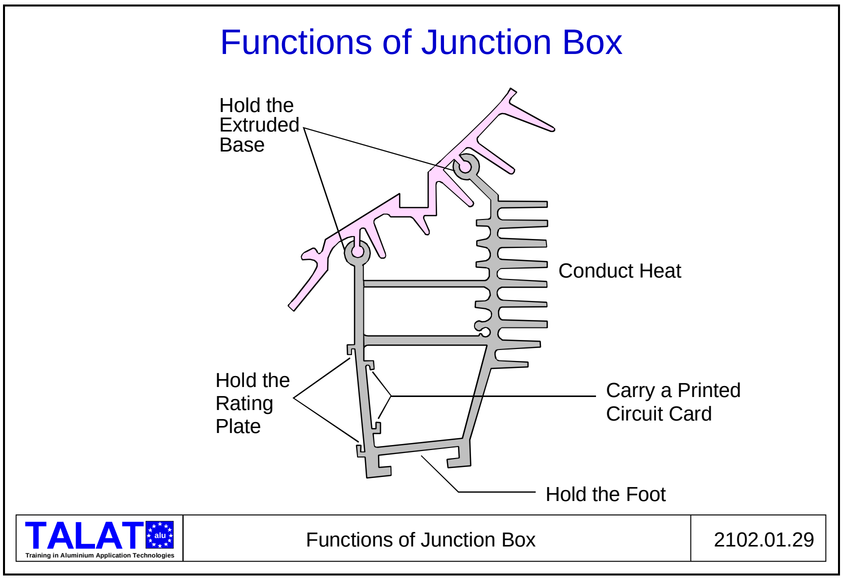
If we choose a solution made of extrusions, the fixture will consist of two parts: an extruded casing (1) and end brackets (2), see **Figure 2102.01.27.**



The functional requirements for the extruded casing are thus as shown in **Figure 2102.01.28**:



A further set of functional requirements applies to the junction box (3), see **Figure 2102.01.29**:



Initially, we planned to weld the junction box to the rest of the light fixture, but eventually we wondered whether there wasn't a better method of assembly. The extrusion expert proposed further improvements. Why couldn't the junction box, which was also to incorporate several functions, be made from an extrusion? **Figure 2102.01.30** gives an idea of the final solution. Ultimately, the junction box was made of an extrusion designed to be slid into place on the extruded casing.

We do not intend to go into detail concerning the other parts used in the lamp, but we would like to mention that the end brackets will be die-cast, the fixtures for the light sources will be extrusions mounted on the end brackets and the foot will consist of two die-cast halves around a steel ball. **Figure 2102.01.30** shows a picture of the lamp and a cross-section of it.

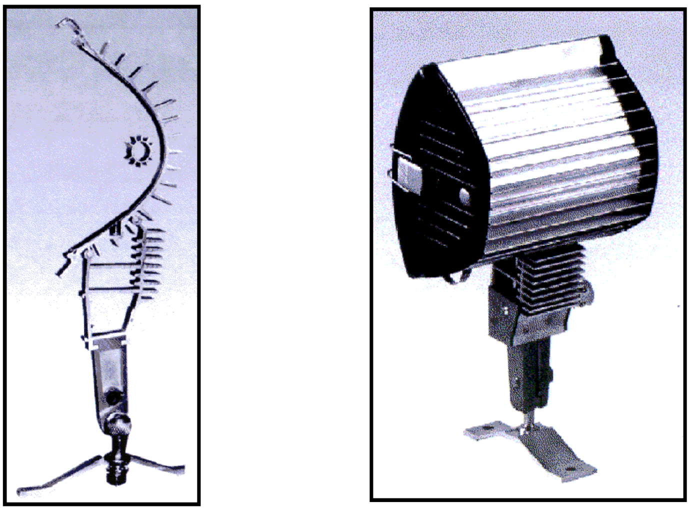


Photo of the Floodlight 2102.01.30

Final Comments

We have not examined the details of this product development task sufficiently in this context to determine whether the solution fully satisfies the specifications. However, the manufacturer tells us that it satisfies the rigorous safety standards which apply, withstands wind loads and temperature variations, and is corrosion-resistant in a saline environment. The lamp is light and easy to move and set up at the work site. It is easy to replace the halogen light source and the unit requires a minimum of maintenance.

This lamp is approved for offshore use, and it is also sold for outdoor illumination onshore. The product is competitively priced and has been on the market for 20 years.

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List of Figures